The building pathology of early modern London

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Abstract

This thesis is an exploratory study into enteric complaints and respiratory ailments in early modern London between 1500 and 1720. These two diseases are closely associated with urban environments, especially domestic housing, and they killed significant numbers during the study period. Unlike the plague, these diseases were comparatively stable from year to year and this thesis argues that this was largely related to constant exposure to defective buildings. While research into the relationship between housing and health is problematic, mainly because the inadequacy of housing is invariably associated with other hardships, such as poor nutrition and hygiene, this thesis aims to overcome this obstacle by applying new tools borrowed from the modern discipline of *building pathology*. This offers a contextual definition of a building defect and identifies the fundamental requirements of healthful housing. *Building pathology* also draws attention to the interaction of the external environment with buildings; the climate of the study period imposed extreme demands on vulnerable buildings and their services. Although there were variations in the quality of buildings occupied by different sectors of the population, the demands of the climate were largely exogenous to economy and society. Applying building pathology analysis to early modern London identifies conditions that were conducive to the spread of enteric and respiratory diseases amongst the wealthy as well as the poor. The final part of the thesis considers the social epidemiology of enteric and respiratory diseases, that is locating them within communities, spatially and residentially defined and questions whether the study of economic or social groups in the context of these two specific diseases helps or hinders epidemiology.

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Lastly, the past seven years would have been immeasurably harder without the unwavering support of my wife Maggie, our son Peter, particularly in his innovative construction of the on-line database used in my research, and my friend Julia Smith in reading the draft.

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Abbreviations

BRE	Building Research Establishment
LMA	London Metropolitan Archives
ODNB	*Oxford Dictionary of National Biography*
RIBA	Royal Institute of British Architects
RICS	Royal Institution of Chartered Surveyors

PART I: Concepts, Methods and Sources

Chapter 1
Introduction

> The first, and chiefe use of an house is to defend man from the extremity of the winde, and weather. And by receit of comfortable light, and wholesome aire, into the same to preserve mans body in health.[1]

This thesis is an exploratory study into building-related illnesses in early modern London. The approach will involve taking an historical study and using new tools borrowed from the principles and practice of *building pathology* for further enlightenment. David Mant has studied the pathology of buildings in the modern era and has described how the process of understanding and interpreting research into building-related illnesses is often called 'critical appraisal'.[2] The first step in such an appraisal is the identification of the main question the research is trying to address and the method used to answer it. The identification of the main question not only prompts the asking of further key questions which determine the validity of the research, but also sets limitations on its interpretation.[3] Thus, in the tradition of a critical appraisal this exploratory study opens up new questions about the role of defective housing on the health of the population in early modern London but it is acknowledged that the research presented does not fully answer all the important questions raised by the *building pathology* approach; this gives rise to future directions for research and these are discussed in the concluding Chapter.

The main question this thesis is seeking to address is, what was the influence of housing, building policies and practice on the health of London's early modern population? The origins of this question are derived from the findings of socio-

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[1] Robert Monson, *A Briefe Declaration for What manner of Special Nusance concerning private dwelling Houses, a man may have his remedy by Assize, or other Actions as the Case requires* (London: Printed by The Cotes, for William Cooke, 1639; EEBO), p.1.

[2] David Mant, 'Understanding the problems of health and housing', in Roger Burridge and David Ormandy (eds.), *Unhealthy Housing, Research, Remedies and Reforms* (London: Spon 1993), p.4. This was published when Mant was a Clinical Lecturer and honorary consultant in Public Health Medicine at the Department of Public Health Medicine and Primary Care at the University of Oxford.

[3] Ibid.

medical history, and these are considered below. Discourses in *building pathology* have raised key questions relating housing conditions to ill- health: how far should modern indicators pertaining to structural condition, possession of the basic amenities and density of occupation be related to those of an earlier period in history? Of what significance is the 'form' of dwelling, for example, whether it is a single house, multi-occupied or a combined live-work building? How far should the location and the environment of housing rather than the condition of the individual dwelling be taken into account? [4]

The *building pathology* approach has identified a large number of potential building defects, which may have contributed to the small number of conditions necessary for the spread of enteric and respiratory complaints; this accounts for more Chapters being dedicated to the former. This thesis is organised into three parts. Within the context of my primary and secondary sources, Part One sets out the model of the 'building pathology analysis', and considers the conceptual and methodological challenges facing this exploration into the health hazards of London's early modern housing. Through this process the parameters of health and housing research are identified. Although conflagration, bomb damage and redevelopment have all played their part in sweeping away large numbers of early modern buildings, there are physical remains and city is also rich in primary source material, and the following have been used in this thesis: panoramas and maps; pictorial and photographic evidence of buildings surviving into the nineteenth and twentieth centuries; the remains and fragments of existing buildings; archaeological excavations; records of property holdings and management including repairing and rebuilding; and contemporary reports on buildings and their condition. The chronology of these sources discussed in Chapter 3 has been broadly determined through the *building pathology* approach, initially focusing on the external built environment, then onto the interior and the interaction of the buildings with occupants. Thus, the panoramas

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[4] David Byrne and Jane Keithley, 'Housing and the Health of the Community' in Burridge and Ormandy (eds.), *Unhealthy Housing,* p.60. At the time of publication both Byrne and Keithley were based at the University of Durham. Byrne was a senior lecturer of Sociology and Social Policy and Keithley was the Director of the Institute of Health Studies. They were co-authors with others of *Housing and Health: The relationship between housing conditions and the health of council tenants.*

and maps provide contemporary views and themes of the wider city, whereas smaller areas of the city and individual dwellings are shown in pictorial and photographic evidence. Further clues of individual buildings are provided by an analysis of existing buildings but with relatively little evidence remaining above ground the analyses moves onto the reports of archaeological excavations. It is acknowledged that there could be scope for a fuller engagement of archaeological information on the built environment but the approach has been to focus on those reports relating to specific construction details; this is discussed in Chapter 3. The interaction of buildings with people is brought into focus in the records of property holdings and management together with the certificates of the City's Viewers and Surveyors. The expectations of the occupiers of buildings are given in these sources, particularly in the context of rebuilding, alterations, maintenance and the way in which the buildings were used.

Part Two is the 'building pathology analysis' and is referred to as such throughout this thesis, and here the function and performance of the buildings are examined mainly through the eyes of the City's Viewers and Surveyors. The reports produced by these building inspectors transports us back to the streets and buildings of early modern London where we are given insights into the day-to-day maintenance of timber-frame and brick-built buildings. Images of leaking roofs and gutters are formed through reading the many reports, along with descriptions of leaning walls, decayed roof and floor timbers and leaking privies. The reports of the Viewers and Surveyors appointed either by landlords, aggrieved neighbours, the City or through statutes were written in the context of enforcing lease covenants, bye-laws, proclamations and acts of Parliament. Although these building inspectors make a considerable contribution to the 'building pathology analysis' it is the collective application of the sources that is of great value in reconstructing the dwellings and their defects and they have been used in the creation of 'Building Audits' and 'The Building Pathology Database' appendices to the thesis; these are discussed in more detail below in Sections 1.3 and 1.4 respectively.

The main lines of the conclusions to this thesis emerge in the research-based 'building pathology analysis'. Although the final part of this thesis draws on those conclusions, the archival research and information are deliberately placed in the background in the exploration of the central concept of 'social epidemiology' of housing. This term was coined by David Byrne and Jane Keithley and involves the

study of the social relationships between housing and health and the patterns of disease that result from those relationships.[5] The remainder of this chapter will outline some general theories pertaining to the waxing and waning of diseases in the built environment and the historiography it addresses. Although this thesis has been conceived within the modern discipline of *building pathology* the aim is not to lose sight of the fact this this is a historical study. Thus, the application of *building pathology* along with defining defects, identifying the fundamentals of healthful housing and the relationship between defective housing and ill-health are all considered in the context of early modern London.

1.1 The urban ecology

The focus on building-related illnesses in this thesis arises from a cliché of socio-medical history which points out that 'the massive improvement in the health of populations of urban industrial societies since the late Victorian period is far more a consequence of collective intervention in the environment than it is of the development, and even provision of curative health care.'[6] Thomas McKeown was probably one of the most prominent post-Second World War exponents of this opinion and in his view hygienic measures in the environment were responsible for at least a fifth of the reduction of the death-rate between the mid nineteenth century and today.[7] McKeown considers that in this context the initial decline in mortality was brought about by the purification of water and sewage disposal, but he recognises that environmental measures were extended in the twentieth century by improvements in working and living conditions.[8] With regard to the contribution made by inoculation he concluded:

> With the exception of vaccination against smallpox, whose contribution was small, the influence of immunization and therapy on the death-rate was delayed until the twentieth century, and had little effect on national mortality trends before the introduction of sulphonamides in 1935.[9]

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[5] Ibid.

[6] Ibid. p.41.

[7] T. McKeown, *The Role of Medicine* (Oxford: Blackwell, 1979) pp.76-78.

[8] Ibid.

[9] Ibid. p.78.

Roy Porter agrees that the figures lend their support to the 'McKeown thesis'.[10] Porter states that in 1869 there were 716 deaths from typhus in London; in 1885 this had been reduced to 28; at the beginning of the twentieth century there were none. Similar reductions in mortality rate could be shown for other infectious diseases. Tuberculosis began a remarkable decline killing perhaps 500 out of every 100,000 Europeans in 1845, with consumption reducing slowly but continuously to 50 per 100,000 by 1950. Curative medicine played little part in that transition as the disappearance began before Koch discovered the tubercle bacillus. By the time antibiotics were discovered and introduced, tuberculosis in cities such as New York had fallen to eleventh place in the death lists. Porter notes that the mortality graphs for most of Europe's fatal crowd diseases had all fallen significantly before antibiotics had been marketed. Whooping cough killed 1,400 children out of every million in 1850, but one hundred years later deaths were less than ten per million. Scarlet fever behaved in the same way and measles, typhus, pneumonia, dysentery and polio all share similar histories. Their retreat had a dramatic impact on the European population, so much so that Porter concludes that:

> By 1900 civilization had lost its biological population check: infectious disease. After centuries of hostile encounters, humans and microbes found a new adjustment with little interference from drugs or vaccines. In some cases the microbe became less virulent (measles and diphtheria) or the human host more resistant (tuberculosis)… [due to] a collective effort in addressing the problems of public or community health.[11]

Thus, the study of the urban ecology requires consideration of the consequences of large numbers of people living together over time. High population densities in early modern towns created the conditions in which disease could spread easily. The study of the demography of early modern towns suggests that 1520 is an appropriate year to start an analysis of growth in English urban populations.[12]

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[10] Roy Porter, *The Greatest Benefit of Mankind, A medical History of Humanity from antiquity to the present* (London, 1997) p.427.

[11] Ibid.

[12] E.A. Wrigley, 'Urban growth and agricultural change: England and the continent in the early modern period', *Journal of Interdisciplinary History*, 15, 1985 pp. 863-728; Chris Galley, *The Demography of Early Modern Towns: York in the Sixteenth and Seventeenth Centuries* (Liverpool, 1998), p.3.

Figure 1.01 John Strype, *A New Plan of the City of London, Westminster and Southwark*, frontispiece to his edition of John Stow's Survey, 1720; *A survey of the cities of London and Westminster*.

The *People in Place* research project has considered the relationship between the growth in the built environment and health in London between the years 1550-1720.[13] With regard to London, I have followed the convention that 'the City' (with a capital letter) refers to the institution within and near the ancient walls, and to its government, while 'the city' means the geographical area illustrated in figure 1.01.

The thesis starts in 1500 so as to provide a long context for the focus on the mid-seventeenth century and early eighteenth century. Amongst other things, this contextualisation highlights the perpetuation of traditional building techniques and some long-established local byelaws as strong undercurrents in the evolution of building forms and legislation.[14] London has been selected as the focus of this thesis because of its relative size and rate of growth. According to Finlay and Shearer's population analysis, London grew from a city of 120,000 in 1550 to 200,000 in 1600, to 375,000 in 1650, and 490,000 in 1700.[15] Vanessa Harding's review of the published evidence gives a different pattern, with lower figures for the earlier period (86,000 for the city centre and the north and east fringe) and 580,000 for the period around 1700.[16] The engagement of *building pathology* invites comparative study. Although London's growth rate was remarkable other towns often matched or even exceed these rates of growth. Norwich grew faster than London during the late seventeenth century, as did Bristol in the first half of the eighteenth century.[17] In 1520

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[13] Vanessa Harding, *et al People in Place: Families, Households and Housing in Early Modern London* (London, 2008).

[14] McKellar describes how the building trades in early modern London were still essentially medieval in structure in Elizabeth McKellar, *The Birth of Modern London: The development and design of the city 166-1720* (Manchester University Press, 1999), p.71. Guillery has discussed the perpetuation of traditional building practices and custom in the context of modernity: 'the new in the context of what has already been there', in Peter Guillery, *The Small House in Eighteenth Century London* (Yale University Press, New Haven and London in association with English Heritage, 2004) pp. 2-3.

[15] Roger Finlay and Beatrice Shearer, 'Population, Growth and Suburban Expansion' in A.L. Beir and Roger Finlay (eds.) *London 1500-1700: The Making of the Metropolis* (London and New York), 1986, pp.37-56.

[16] Vanessa Harding, 'The Population of London, 1550-1700: A Review of the Published Evidence', *London Journal*, 15.2 (1990), pp.111-28.

[17] Galley, *The Demography of Early Modern Towns,* p. 5.

the population of Norwich was 12,000 and 10,000 in Bristol; by 1700 these had increased to 30,000 and 21,000 respectively. Between 1520 and 1700 London was 20 times greater than its nearest rival of Norwich. Next in the urban hierarchy were a group of provincial capitals with populations in the region of 10,000 and below these came an expanding group of towns such as Worcester, King's Lynn and Chester with population in excess of 5,000.[18]

London dominated its provincial cities, which was not generally the case with most European capitals.[19] Nevertheless, there were networks of large provincial cities on the continent. Holland, the most urbanized European country at this date, had 19 cities with populations in excess of 10,000, although Amsterdam's population was only 65,000. Likewise on the Italian peninsular there were 58 cities with population in excess of 10,000. In France there were 13 provincial centres larger than Norwich [20] and it is the French capital that Vanessa Harding considers is 'the most appropriate comparator for early modern London'.[21] One of the most important similarities between them was their great size: 'both appear to reached and passed 450,000 inhabitants by 1670 making them the two largest cities in northern Europe and among the largest in the world known to contemporary Europeans.'[22] Both cities had a history of centuries of development and redevelopment on the same spot, resulting in 'a congested urban plan that was invested with meanings derived from traditional uses and ownerships but modified by newer practices.'[23] London and Paris also shared many of the pressures and problems of urban living with smaller centres. Comparisons will be made with Paris in the thesis but also other cities and towns in the context of building practices and regulation. Mortality rates in early modern towns were high and usually exceeded those in rural areas. London not only

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[18] E.A. Wrigley, 'Urban growth and agricultural change: England and the continent in the early modern period' *Journal of Interdisciplinary History,* 15, p.688.

[19] Galley, *The Demography of Early Modern Towns,* p. 5.

[20] Ibid.

[21] Vanessa Harding, *The Dead and the Living in Paris and London, 1500-1670* (Cambridge University Press, 2002), p.3

[22] Ibid.

[23] Ibid.

dominated England's urban hierarchy at all times during the study period but also suffered the highest mortality rate.[24]

In 1662 John Graunt, in his *Natural and Observations…Upon the Bills of Mortality,* provided a contemporary view on health in the built environment. He considered it was not the epidemic but 'The *Chronical* Diseases' that were the key to whether a place is healthful or not. He observed 'that in Countries subject to the great Epidemical sweeps men may live very long, but where the proportion of the *Chronical* distempers is great, it is not likely to be so; because men being sick and always sickly, cannot live to any great age.'[25] This is a prescient statement, for Byrne and Keithley have concluded that the argument is simple enough: 'it is based on the premise that a lot of minor ill-health adds up to serious problems.'[26] Graunt's work was based on a quantitative analysis of weekly Bills of Mortality compiled by London parish clerks that gave numbers and causes of death. Wear describes how Graunt's numerative approach was very much in keeping with the 'new science' of the Royal Society and marked the start of the endeavour of relating deaths and types of deaths to environmental causes in a quantitative way.[27]

Harding has added currency to Graunt's observations by noting that plague, London's most famous killer disease, may have been present in London in two years out of three, but only a handful of deaths occurred in most years: 'The overall pattern is one of few if any deaths in most years, punctuated by extreme epidemic years in which thousands of plague deaths were recorded.'[28] Other 'epidemicall' disease ('*purples, spotted-fever, Small-Pox,* and *Measles,* according to Graunt) had different cycles and recurrences, at times coinciding with plague. Unlike the plague, however,

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[24] Galley, *The Demography of Early Modern Towns*, p.30; Landers, *Death and the Metropolis,* p. xix-xxi; Harding et *al, People in Place,* p.29.

[25] John Graunt, *Natural and Political Observations… Upon the Bills of Mortality, 1676* (Early English Books On-line, Bib name / number: Wing / G1599A), p.16.

[26] Byrne and Keithley, 'Housing and the Health of the Community,'p.60.

[27] Andrew Wear, 'Making Sense of Health and the Environment', in Andrew Wear (ed.) *Medicine in Society: Historical Essays* (Cambridge University Press,1992), p.129.

[28] Vanessa Harding, 'Housing and Health in early modern London', in Virginia Berridge and Martin Gorsky (eds.), *Environment, Health, History* (Palgrave Macmillan), p.31.

these diseases killed significant numbers in most years with regular peaks, suggesting that they were both endemic and epidemic.[29] Among the '*Chronical* diseases' listed by Graunt 'whereunto the city is most subject' [were] *consumptions, Dropsies, Jaundice, Gowt, Stone, Palsie, Scury, rising of the Lights,* or *Mother, Rickets, Aged, Agues, Feavers, Bloody-Flux,* and *Scowering.*[30] Harding has observed that some of these were clearly infectious, some not, and they were of very differing significance in the mortality pattern, but as a group (apart from 'ague and fever'), they were comparatively stable from year to year, a constant strong undercurrent.[31]

Enteric disorders, such as griping or plague in the guts, bloody flux, scouring and vomiting, figure quite prominently in the '*Chronical*' diseases, along with respiratory complaints such as consumption, cough, 'tissick' pleurisy and quinsey. Enteric diseases were particularly severe in the third quarter of the seventeenth century, accounting for over 12% of non-plague deaths in the 1660s to 1680s, declining to about 9% by 1700.[32] Respiratory ailments were certainly a major cause of death in early modern London. In Graunt's tabulation of the mid-seventeenth century Bills of Mortality, they produced around 25% of deaths across London in non-plague years. 'Consumption' alone caused 15-20% of non-plague deaths between 1629 and 1636, rising to nearly 24 per cent in the later 1640s and 1650s; in 1660, they were still over 20 per cent. After 1665, while absolute numbers of deaths attributed to consumption remained high, they declined as a proportion of all deaths, though this was partly the result of increasing infant and smallpox mortality.[33]

The former brings to light one of the most significant elements in the mortality profile: the poor and worsening survival of babies and infants. *People in Place* has observed the 'Worsening infant mortality in the outer suburbs no doubt owed much to the increasing population numbers and density, but the fact that the rates continued to rise in the inner city, despite the renewal and improvement of the

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[29] Ibid. p.32.

[30] Ibid.

[31] Ibid.

[32] Harding, 'Housing and Health,' p.37.

[33] Ibid., pp. 38-39.

urban fabric after the Fire of 1666 and the decline in the city-centre population is striking.'[34] High infant mortality within the wealthy part of London has another raised key question whether exploring the correlation of housing and health should be limited to social groups or extended to those members of society who were particularly vulnerable, which would also include the elderly and sickly. It is not possible to deduce from the Bills of Mortality that poor housing conditions contributed to, or accelerated the deaths of the elderly and those who were already sick. The term 'Aged' in the Bills is clearly a generic term but it would appear that this refers to death through old age rather than an elderly person dying through some other cause.

Having identified enteric and respiratory diseases as two significant killers throughout the study period, this thesis will focus on the building defects and conditions, which may have contributed to these ailments. This exploration will not only consider overcrowding but the standard of construction and maintenance for as M.J. Power suggested in 1972, 'maybe living in the cramped conditions of a seventeenth-century 'Coronation Street' did not affect a man as much as a leaking roof, damp walls or the ruinous condition of his house.'[35]

Thus, in attempting to answer the main question, a wider understanding of London's early modern housing in the context of building-related illnesses will need to be developed. A holistic approach is required, such as that used by Mary Dobson in her book *Contours of Death and Disease in Early Modern England.*[36] Dobson's work is the intellectual origin of this thesis, where she used a broad interdisciplinary perspective, and a wide range of sources, particularly parish registers, for the south-east of England. Economic and demographic factors are but two variables mentioned by Dobson and she has observed that features of the environment accounted for some spatial variations in disease and mortality, but many epidemiological patterns were far more complex, reflecting the significance of a range of environmental, social,

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[34] Harding *et al*, *People in Place*, p.29.

[35] M.J. Power, 'East London housing in the seventh century' in Peter Clark and Paul Slack (eds.) *Crisis and Order in English Towns 1500-1700* (London), 1972, p.244.

[36] Mary J. Dobson, *Contours of Death and Disease in Early Modern England* (Cambridge University Press, 2002).

economic, biological and demographic variables.[37] Dobson has suggested that 'in trying to reconstruct past epidemiological landscapes, it is now time to move beyond real wages, and move beyond airs, water and places to avoid the temptation to search for any single determinant of mortality patterns and their changes over time and space.'[38] This thesis will seek to avoid such temptations but attempt to demonstrate the important part that housing plays in the environmental determination of health. Dobson's focus is on the wider external environment, whereas this thesis will use *building pathology* to examine the interaction with the internal environment. This approach is based on the premise put forward in discourses in *building pathology* by Burridge and Ormandy:

> The primacy of shelter as an essential requirement of human existence renders it liable to inquiry into its sufficiency for the preservation of life. Since the primary function of housing is to provide protection from the hazards and exigencies of the outdoor environment, it is pertinent to scrutinise its effectiveness in performing the task and to ensure that it does not replace the external dangers with fresh internal threats.[39]

Consideration of the interaction between the external and internal environment will be made in the context of the size of the city in relation to its natural and physical environment. Despite its much greater size than other English cities, the London illustrated in fig. 1.1 and described by Daniel Defoe in 1720 as 'monstrous' was in fact a compact town stretching approximately four miles from east to west.[40] Thus early modern London, lying within its low lying river valley, fed by various tributary streams, and flanked by isolated pockets of marshland would still have been influenced by the natural physical environment and this is discussed in Chapters 4-6.

The thesis has important things to say about the difference between the housing of the rich and poor, adding further support to the argument that we need to

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[37] Ibid. pp.493-539.

[38] Ibid. p.77.

[39] Burridge and Ormandy (eds.), *Unhealthy Housing*, pp. xv –xvi.

[40] Daniel Defoe, *A Tour Through The Whole of Great Britain*, edited by Pat Rogers (London, 1986), p.101.

move away from considering the housing of the poor as slums.[41] Graunt's analysis of the Bills of Mortality covered a variety of social groups and is key to this 'social epidemiology' exercise. The emphasis on the ill-health of the poor is an important counterweight to the awareness of the well-being of the wealthy. To paraphrase Peter Guillery, attention to the two extremes, however, obscures those who came in between, such as artisans and labourers.[42] Having identified the main question in this research, we now need to consider the context within which it is to be addressed.

1.2 Modern writers on building policy and practice

The following is a chronological account of the work of writers who I consider offer the most useful contribution to the themes of building policy and practice in early modern London. In 1925 M. Dorothy George put forward an opinion on early modern building policy in her *London Life in the Eighteenth Century*.[43] According to George the 'peculiar squalor and infamy of the courts and alleys built in the seventeenth century was partly due to the building policy begun by Elizabeth and carried on by the Stuarts and Cromwell.'[44] She noted that buildings of a sort were put up in yards behind thoroughfares and in the courts of existing houses and by encroachments on wasteland. George concluded that the object must have been to escape notice and build in such a way that demolition would be no great loss. Overcrowding and poverty continued the process long after the restrictions had been given up.[45] This account is a useful starting point for this thesis regarding the possible failures in

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[41] See Alan Mayne and Tim Murray (eds.), *The Archaeology of Urban Landscapes: Explorations in Slumland* (Cambridge 2001), p.3. These writers argue that the nature of life in the poorest sections of the great cities of the western world was much richer than has been traditionally portrayed.

[42] Guillery, *The Small House in the Eighteenth Century London* (Yale, New Haven and London, 2004), p.33. Jonathan Barry and Christopher Brooks also look to focus on the social group between the two social extremes in their book *Middling Sort of People: Culture, Society and Politics in England, 1550 - 1800* (Palgrave MacMillan, 1994). See also Margaret Hunt, *The Middling Sort: Commerce, Gender and the Family in England, 1680 -1780* (California, 1996).

[43] Dorothy George, *London Life in the Eighteenth Century* (Penguin, Reprinted in1965), p.82.

[44] Ibid.

[45] Ibid.

statutory requirements as well as those pertaining to the function and performance of buildings.

George's focus is, however, on the housing of the poor whereas this thesis involves an investigation into the dwellings of all social groups. A more generalised account on housing policy was provided in 1934 by the Danish architect and town planner Steen Eiler Rasmussen in his highly individualized account of London's growth, *London: The Unique City.* He gave some indication of London's development during this study period but the pre-Fire house is largely ignored. On face value his book appears more an architectural and planning treatise than an historical study but as is noted later in Chapter 4 of this thesis, he made significant observations in relating town planning issues to public health.[46] Norman Brett-James gave another generalized account in 1935 of London's expansion in the seventeenth century, but he also provided a valuable topographical survey of growth.[47] The specific observations on attempts to control the expansion are also of great value to the town planning and external environmental issues examined in chapter 4, even though there is a lack of information on the house type and construction.

T.F. Reddaway's *The Rebuilding of London after the Great Fire* was published in 1940, and gave a thorough examination of the Fire's impact.[48] He concentrated on the city centre and the post-Fire house and for the first time a detailed account of the labour and materials for housing was considered, along with the legislation. Although some of the most recent writers on the subject have sought to amend Reddaway's rather favourable account of the rebuilding of the city, in my view this author displays a great understanding of the pragmatic approach the authorities were forced to take. His assessment of the performance and function of the city's built environment ten years after rebuilding is of great value to the building pathology analysis in Chapters 4-6.

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[46] Steen Eiler Rasmussen, *London: The Unique City* (Penguin Books, first published in 1934 and reprinted in 1961).

[47] Norman Brett-James, *The Growth of Stuart London* (London and Middlesex Archaeological Society with George Allen & Unwin, 1935).

[48] T.F. Reddaway, *The Rebuilding of London after the Great Fire* (Jonathan Cape, 1940).

The definitive account of late seventeenth- and eighteenth- century speculative development in London remains to this day Sir John Summerson's *Georgian London,* first published in 1945.[49] Although Elizabeth McKellar severely qualifies some of Summerson's conclusions, she does refer to this book as 'a masterpiece of architectural interpretation and reconstruction.'[50] Summerson's reconstruction of Georgian London is a response to the destruction of parts of London following the Second World War. He intended to convey the totality of London's development for this period and to try and place design developments within a broader historical context. Although it would appear that Summerson's period of study begins where mine ends, he places Georgian London (1714-1830) into context by describing the development of London from 1615 in his 'Air View' chapter. In asking the reader to imagine that he or she is suspended a mile above the city, Summerson creates an image that illustrates changes in the built environment, such as the results of the proclamations of Elizabeth and James restricting new building and these are discussed in detail in chapter 4 of this thesis. Summerson's view suggests that 'we see a change in density, not size. We see that in the city green plots and great buildings become fewer and brick gables multiply; we see the belt around the walls swell with smoke and poverty…'[51] McKellar has written a critique of Summerson's work, but observes that despite the lack of footnotes and a small bibliography, she found that many of his 'throw-away lines and sweeping pronouncements to be correct.'[52] Summerson also places the style of Georgian house into context by referring to an example of a house type built by Nicholas Barbon between 1670 and 1700 (figure 1.02).

For Summerson, this style of house represented the beginning of the modern London house and the forerunner of the Georgian buildings with which he was principally concerned.[53] This is crucial to the analysis of building performance in

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[49] John Summerson, *Georgian London* (Harmondsworth, Penguin, 1978 edition).

[50] Elizabeth McKellar, *The Birth of Modern London,* p.xi.

[51] Summerson, *Georgian London*, p.18.

[52] McKellar, *The Birth of Modern London,* p.xii.

[53]Summerson, *Georgian London*, p.47.

chapter 5 of this thesis and also highlights a recurring theme throughout the study period; there is no clear break from one building style or form of construction to another, reflecting the conservative nature of construction.

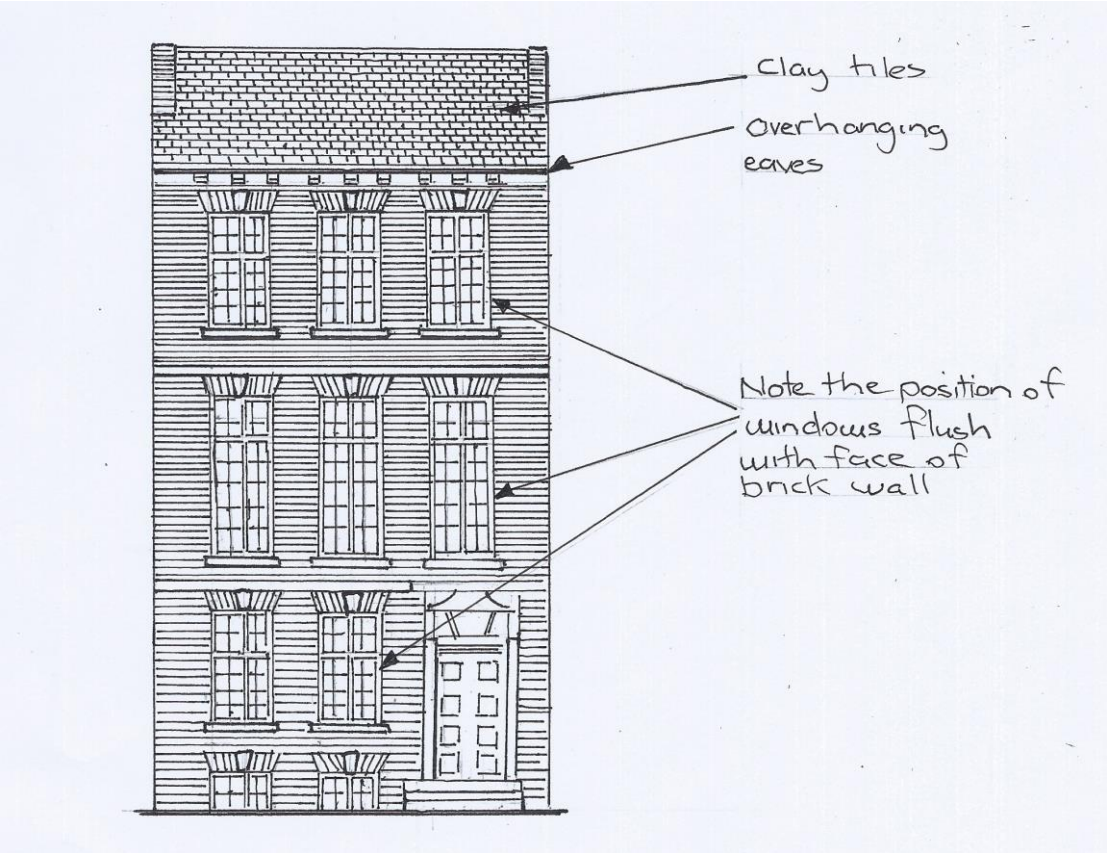

Figure 1.02- A house of the type built by Nicholas Barbon between 1670 and 1700, adapted from Summerson, *Georgian London*, p.47 (sketch by S.M. Cornish)

Dan Cruickshank and Peter Wyld reinforce the tendency towards conservatism in building in their 1975 detailed study of London's Georgian buildings. A large number of detailed drawings are included in their *Art of Georgian Building*, illustrating how the eighteenth-century terraced house functioned and performed and the aesthetic and technical logic which informed it. Despite the significant detail provided in the drawings, there is no reference to damp-proof courses in the ubiquitous parapet walls or to the base of the walls to prevent respective penetrating

and rising damp. Nevertheless other technical issues are referred to, not least the perpetuation of the timber frame hidden behind the post-Fire brick facades. [54]

Linking the work of the writers in the 1970s through to the 1990s is John Schofield of the Museum of London. Between 1984 and 1993 Schofield produced three authoritative books on London's pre-Fire buildings.[55] At the time of writing *The Building of London from the conquest to the Great Fire*, and *The London Surveys of Ralph Treswell*, he was a Field Officer at the Museum of London, in charge of various excavations. By the time *Medieval London Houses* was published, he was Curator of Architecture at the Museum. Schofield presents a comprehensive overview of the topography of the pre-Fire city, pursuing the theme of historical reconstruction in describing the streets, many religious houses and fine civic buildings. It is his description of the Tudor house and those buildings constructed in the early seventeenth century which have proved of great value to this thesis. Schofield includes illustrations of house plans, individual rooms, spaces and their functions, the roofs, floors, and windows, the materials of construction, and decoration. Of particular importance is Schofield's reference to an early attempt to place a damp-proof course into timber-framed buildings, which is considered in detail in Chapters 4 and 5.[56] He has also related these timber-framed buildings to the wider historiography of other early modern towns such as King's Lynn and York.

In 1999 the architectural historian Elizabeth McKellar sought to 'move away from an analysis centred on [architectural] style alone, to a more wide-ranging socio-economic approach as a means of explaining architecture and its place within the wider culture.'[57] In *The Birth of Modern London 1660-1720*, McKellar draws our attention to the social relationship of housing in the post-Fire period in referring to Strype's commentary on the social standing of different areas of the city. Strype

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[54] Dan Cruickshank and Peter Wyld, *London: the Art of Georgian Building* (The Architectural Press Ltd: London Architectural Book Publishing Co: New York, 1975), p.17.

[55] John Schofield, *The Building of London from the conquest to the Great Fire* (London, 1984), *The London Surveys of Ralph Treswell* (London 1987), *Medieval London Houses* (Yale, New Haven and London, 1993).

[56] Schofield, *Medieval London House*, Fig 93, page 82 and figs 165-6, p.143.

[57] McKellar, *The Birth of Modern London*, p.1.

describes different areas in terms of 'well', 'good' and 'poor.'[58] McKellar suggests that Strype's work can be used to construct a 'social morphology' of the city in a similar fashion to that of Charles Booth in his great book *Life and Labour of the People of London of 1889-9.*[59] McKellar has, however, concentrated on the mass produced housing of 'the middling sort', which saw the adoption of classicism on a large scale in this country for the first time. She has examined in detail the rapid growth in building and the speculative developers who created London's landscape. Despite the classical facades of the 'middling sort' McKellar shows that the 'new city' of London maintained a surprising degree of continuity with traditional architecture. McKellar has confirmed that a timber frame was built behind the external brick walls and this investigation will consider the implications of that in terms of building defects and ill-health. Her primary sources suggest poor as well as good building practices continuing into the late seventeenth century.

Building policy and practice in London's less wealthier suburbs was the focus of Peter Guillery in 2004. He was a senior investigator for English Heritage when he wrote *The Small House in Eighteenth-Century London,* and therefore had first hand knowledge of some of the buildings included in his study.[60] Although focusing on the eighteenth century Guillery, like Summerson before him, also had recourse to the buildings of the seventeenth-century to place his study into context. Guillery has noted the continuation of traditional architecture or, as he calls it the 'vernacular', into the immediate post-Fire era. He has examined the modest domestic architecture of the period on the basis that the houses once inhabited by artisans and labourers can tell us much more about the culture of that period. Guillery also pursues the theme of historic reconstruction, which culminates in three-dimensional drawings of houses. As with the case of Cruickshank and Wyld, although significant constructional details are given, there is no mention of damp-proof courses to the top and bottom of walls.

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[58] Ibid. p.21.

[59] For an account of this work, see Gareth Stedman Jones, *Outcast London: A Study in the relationship between classes in Victorian Society* (Harmondsworth, 1976), pp. 320-1 and 328.

[60] Peter Guillery, *The Small House in Eighteenth Century London* (Yale University Press, New Haven and London in association with English Heritage, 2004).

Following on from his work in the 1980s and 1990s, Schofield has, in collaboration with Richard Lea at the Museum of London, published an archaeological reconstruction and history of the Holy Trinity Priory in Aldgate.[61] From an historic perspective the Holy Trinity is considered important as it reflects the sweeping changes of the sixteenth century in the buildings of London, by showing the 'bizarre buildings cobbled together from parts of the monastic church.'[62] The cobbling together of these buildings reflects the general structural confusion of London's pre-Fire buildings and the implication that brings with regard to building defects and ill-health. Such factors, along with other issues are to be addressed through *building pathology*.

1.3 Building pathology and its application

Medical pathology has been defined as the systematic study of diseases with the aim of understanding their causes, symptoms and treatment. In a medical context, the person becomes the subject of detailed examination and investigation, with consideration given to age, health and lifestyle.[63] A similar approach is relevant in the study of buildings: the house is examined in detail, and defects, symptoms and repairs are considered in the context of the building's age, its overall condition and how it is used. It is this methodical and often forensic practice that has become termed *building pathology*, a concept that has been evolving since the 1980s. This immediately raises the following question: should the emphasis be on the pathology of the individual patient and house or considered collectively in terms of illness in the community and defective buildings? This is addressed later in this chapter and in detail in Chapter 2.

As one would expect with a relatively new concept such as *building pathology*, its definition will be subject to various adaptations and amendments as the discipline evolves. This is demonstrated by three separate, though interrelated, definitions of *building pathology* put forward by the Association d'Experts Européens du Bâtiment et de la Construction (AEEBC, 1994). The first definition was 'the

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[61] John Schofield and Richard Lea, *Holy Trinity Priory, Aldgate, City of London* (Museum of London Archaeology Service, 2005).

[62] Schofield, *The Building of London*, p.145.

[63] David S. Watt, *Building Pathology*, (Blackwell Publishing, 2007), p.1.

identification, investigation and diagnosis of defects in existing buildings'. The second version sought to extend the definition to 'the prognosis of defects diagnosed, and recommendations for the most appropriate course of action having regard to the building, its future and resources available'. The third definition was the most comprehensive where the area of concern was the 'design, specification, implementation and supervision of appropriate programmes of remedial works; monitoring and evaluation of remedial works in terms of their functional, technical and economic performance in use'.[64]

In terms of relating building defects to ill-health, these three definitions represented a retrograde step, ignoring a definition put forward by Hutton and Royston in 1989 where they considered 'the study of failures in the interrelationship of buildings, structures and materials with their environments, occupants and contents.'[65] Dr. Jagjit Singh has developed Hutton and Royston's definition in his consideration of the nexus between defective buildings and ill-health. Singh's definition of *building pathology* is of great value to the thesis where he describes the discipline as:

> The scientific study of abnormalities in the structure and functioning of the building envelope and its parts; it seeks to study the interrelationships of building materials, construction, services and spatial arrangement with their environments, occupants and contents. [66]

The possible confusion in considering various definitions was recognised in 1999 by Dr. David Watt. He observed, however, that despite the various definitions placing a slightly different emphasis on the nature and extent of the discipline, it is clear that *building pathology*, in its widest sense, is concerned principally with defects and associated remedial action.[67] Singh's definition of *building pathology* quoted

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[64] AEEBC (1994) *Academic Guidelines: Policy Regarding Degree Validation,* London and Brussels: Association d'Experts Européens du Bâtiment et de la Construction. CIB W86 Building Pathology (1993) *Introduction.* CIB Report 155 June, quoted in Watt, *Building Pathology*, p.1

[65] Hutton and Royston (1989) *Building Pathology Conference* (BP89), Gomshall.

[66] Dr. Jagjit Singh, 'Building pathology and environmental monitoring; the development of holistic sustainable conservation solutions-an overview' (http://www.healthdvds.co.uk/experts_js.htm downloaded 21 February 2009), p.1.

[67] Watt, *Building Pathology*, p.2.

above is the most relevant to the thesis as it is given in the context of historic buildings. We must be aware, however, that his definition is based on his analysis of such buildings in the twenty first century. The study of hundreds of reports produced by the seventeenth-century Viewers and Surveyors, diagnosing defects and specifying repairs, will assist in engaging Singh's definition into early modern London. A detailed description of the Viewers and Surveyors is given in Chapter 3.

Since the first edition of Watt's book in 1999, *building pathology*, both as a term and as an overall concept, is becoming widely used to define the holistic approach to understanding buildings. This has been driven by the awareness of many property owners, building professionals and contractors that the failure to understand a building has led to the incorrect diagnosis of defects and the implementation of inappropriate repairs. In order to assess the condition of a building, and attempt to understand how it will perform in the future, consideration must be given to various levels of information. Before attempting to define what is wrong with a building, it is essential first to consider the various aspects of design and construction that will have influenced how it was built and how it has performed. As relatively few early modern houses remain, this involves the process of historical reconstruction. The theme of historical reconstruction is central to this thesis and enables us to consider the statutory requirements along with the function, performance and user requirements of early modern buildings. Other levels of investigation will need to be addressed including variations in design, material selection and utilisation, and methods of construction.

Engaging *building pathology* for the study of early modern London therefore requires a detailed knowledge of how various buildings were constructed used, occupied and maintained, and the numerous mechanisms by which their structural, material and environmental conditions were affected. In order to make comparisons between the buildings studied in the 'building pathology analysis' a method of collecting and presenting the information was required. *Building pathology* has recognised that in the past the property industry's assessment of buildings has typically lacked accurate and comparable information. The practice of *building pathology* demands a broad and detailed assessment of buildings and this has resulted

in the production of building audits.[68] These are checklists and have been adopted in this thesis and form the basis of Appendix A. The audits summarise a holistic approach, recording how the buildings were constructed, serviced and used. The interaction between people, place and the environment requires consideration in collecting and comparing this information and this is best illustrated in fig. 1.03. This pictorial representation is essential to understanding the context within which the buildings of the early modern era are to be considered; hereafter, figure 1.03 will be cited as the 'contextual model of buildings'.

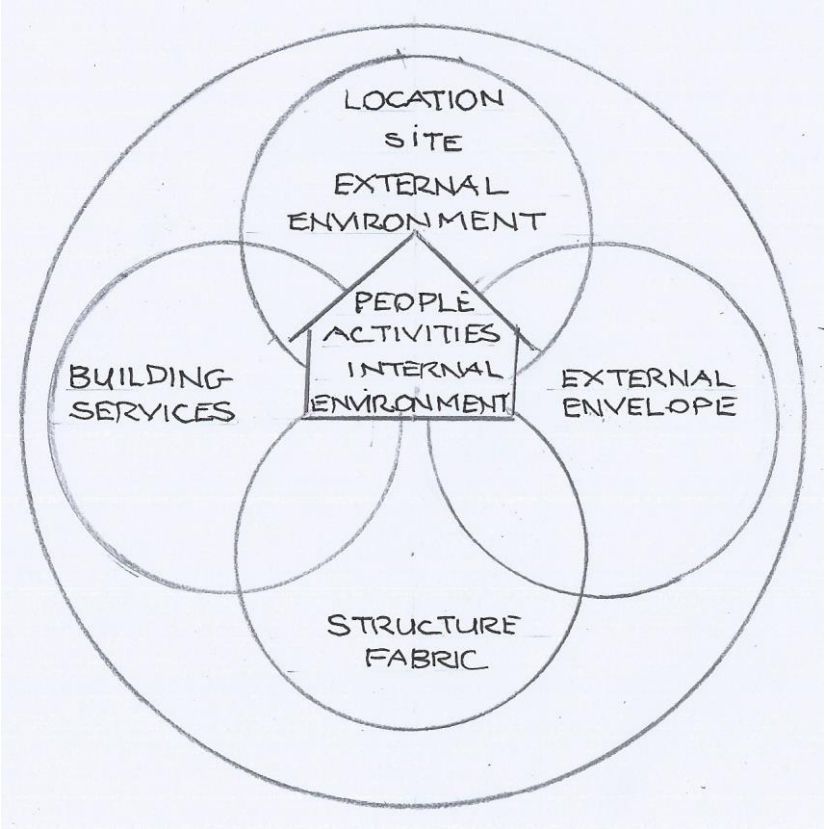

Fig. 1.03. Buildings in context, adapted from Watt, *Building Pathology*, p.3, drawn by S.M. Cornish

As Watt notes, '[building pathology] is by necessity, an interdisciplinary approach and requires a wider recognition of the ways in which buildings and people respond to each other.'[69] In his view *building pathology* analysis is often of a forensic

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[68] Watt, *Building Pathology*, pp.82-3.

[69] Watt, *Building Pathology*, p.ix.

nature, which involves the investigation as to why and how a building failed. In seeking the nexus between building and human pathology, writers from other disciplines are therefore among my primary and secondary sources and these include: architectural and social historians; archaeologists; medical historians; researchers and practitioners; structural and civil engineers; material scientists; contemporary craftsmen, Viewers and Surveyors. In addition to drawing on professionals and craftsmen, the comments and observations of lay contemporaries have also been included.

Elizabeth McKellar has highlighted the many 'pitfalls and perils'[70] of an interdisciplinary approach but the aim of this thesis is to demonstrate that the inevitable superficialities which result are counterbalanced by new insights to be gained from drawing on the tools offered by *building pathology.* This modern discipline is of great value to this historical study for it has been shown that, within acceptable tolerances, human physiology and the function and performance of building structures and materials have not changed significantly since the start of the study period.[71] The next stage of this Chapter is to consider the definition of a building defect in the context of the study period.

1.4 Defining a building defect in early modern London

Building pathology defines a defect as a failing or shortcoming in the statutory, function, performance, and user requirements of a building which may manifest itself in the structure, fabric or services of a building.[72] These four requirements will be the focus of the building pathology analysis in Chapters 4-6 and their definitions are now considered.

The possible failings in statutory requirements are considered in Chapter 4 and are not only considered in terms of buildings failing to comply with the

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[70] McKellar, *The Birth of Modern London,* p.2.

[71] There are inevitably variables which are addressed in this thesis but see also Porter, *The Greatest Benefit,* Anand and O'Connor, *Pathology,* (Mosby Elsevier, 2007), Singh, 'Building Pathology', Watt, *Building Pathology,* Professor Malcolm Hollis, *Surveying Buildings* (RICS Books, 2005), and Watt and Swallow, *Surveying Historic Buildings* (Donhead Publishing, 2004).

[72] Watt, *Building Pathology*, p.96.

regulations but as to the form they took, particularly whether the provisions of the statutes were themselves inadequate or inapplicable, or that they were not being observed or policed. Consideration also needs to be given to whether the regulations were reactive rather than proactive, and if so, what was the result in the delay in dealing with defects and the consequential effects on health? Chapter 4 will show that there was a lack of statutory requirements controlling building in London in the early part of this study period and building policy was pursued through the Customs of the City, Common Law and proclamations; these three additional sources of building law are given the generic term 'environmental law.'[73] The evolution of statutory requirements developed in the context of the rapid growth of London and together with 'environmental law' made demands on those who designed, built, managed, repaired, maintained, occupied or demolished buildings.

With regard to the second requirement, every building, regardless of its original, intermediate or ultimate use, is expected to fulfil certain basic functional requirements. These requirements are primarily concerned with protection from the external environment and the provision of human comfort. Many of the buildings under examination in this thesis combined seemingly conflicting domestic and commercial activities and the effects of this on health are discussed. As well as satisfying the basic functional requirements noted above, building pathologists consider that a building should meet the following performance requirements (the third requirement): durability, strength and stability, weather exclusion, thermal comfort, fire protection, lighting, ventilation and sanitation.[74] If shortcomings in building performance can be shown, then some consideration must be given to health implications. The emphasis of a building meeting these individual requirements is likely to have varied but Schofield states that as early as 1422 certain small lodgings or rents in Bassishaw Ward were considered defective because none of them had

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[73] Thomas G. Barnes has coined this term,'The Prerogative and Environmental Control of London Building in the Early Seventeenth Century: The Lost Opportunity' (The California Law Review, Volume 58, No. 6 November 1970), pp.1332-1363.

[74] Watt, *Building Pathology*, p. 19. Watt highlights other performance requirements, which are not relevant to the early modern period.

privies.[75] Functional and performance requirements have strong links and are considered together in Chapter 5 where an assessment will be made on the extent to which these requirements were compromised through inadequate regulation, poor design, construction, lack of maintenance and chronic neglect; consequential defects are also considered.

The failure of 'user requirements' pertaining to dwellings is the fourth and final source of a building defect. We must be aware that 'user requirements' in the modern era may be significantly different from those pertaining to the study period. Consideration must therefore be given to the modern definition of 'user requirements' and determine whether this can assist in identifying those within early modern London. The user of a building in the modern era can expect to live and work in a space that satisfies basic human requirements and, in addition, certain needs that are specific to the activities being performed.[76] The ways in which these are met, and whether one is in conflict with the other, is a measure of how appropriate the building is for the activity or activities in question. 'Fitness for purpose' is thus an important measure of how a building matches the requirements of its user.[77] User requirement studies attempt to identify fitness for purpose in terms of activities (the things people do) and human needs (physical, psychological, physiological and social); for a building to be fit for its purpose it must allow the occupants to carry out their activities economically and conveniently, and have a satisfactory environment to suit the user.[78]

Watt has outlined a user requirement study in the modern era and this would typically consider: the classification of the user, for example task orientation; an analysis of activities, such as social interaction; the requirements of space, that is, the circulation in and around the building; environmental conditions, for example sensory stimulation; structural implications, particularly in terms of compatibility; and costs,

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[75] Quoted in *The London Surveys of Ralph Treswell*, p.22.

[76] Watt, *Building Pathology*, p.20.

[77] Ibid.

[78] Ibid.

for example those dedicated to maintaining the building.[79] This is clearly a vast subject and could benefit from a thesis on its own account. Each of the above components of a modern user requirement study do, however, have some relevance to this investigation; it is a question of degree to which each component would have contributed to a building-related illness in the study period.

Early modern London was driven by a commercial enterprise and the users of the buildings aimed to be located near their markets. Power has identified ten groups of occupations in the city centre prior to the Great Fire: three groups selling commodities or services, five craft groups, making and perhaps selling commodities, and two semi-skilled groups.[80] Only the semi-skilled customarily worked away from their homes and therefore a significant number of the buildings were occupied on a 'live-work' basis. Each of these groups would have had specific requirements in order to conduct their business and provide living accommodation within their buildings and this would often involve: internal alterations such as the removal of load-bearing walls; extending into gardens and yards; building an additional storey; creating new window openings while blocking up others; re-directing rainwater goods; enclosing external privies within extensions. If the work was not undertaken correctly the function and performance of the fabric, structure and services of the property and neighbouring buildings could be compromised. The occupants of the buildings may have been exposed to building-related illnesses if the defects were allowed to persist. As already noted only the semi-skilled customarily worked away from their homes but the potential exposure to building-related illnesses for a large part of the population living and working in the buildings takes on a greater significance. This pattern of occupancy appears to have continued into the post-Fire period where, other than a slight fall in population density, the social topography of the city centre did not seem to change greatly.[81]

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[79] Ibid.

[80] M.J. Power, 'The social topography of Restoration London' in A.L. Beier and Roger Finlay (eds.) *London 1500-1700:The Making of the Metropolis* (Longman, 1986), p.210.

[81] Vanessa Harding, *et al People in Place: Families Households and Housing in Early Modern London* (London, 2008), p.34.

Early modern 'user requirements' can be identified through property histories and the reports of the City's Viewers and Surveyors. It will be shown that leases, which were forged through the negotiations between landlord and tenants, would often set out the latter's requirements in using the building. In the case of the City's Viewers and Surveyors, they were often responding to complaints from occupiers in many cases, aggrieved that a defect or the action of a neighbour was preventing them from enjoying the use of their properties. Many examples will be referred to in this thesis and through these sources we can gain a wider experience of the expectations of almost anyone of fixed abode and regular income. Watt has observed that the servicing of historic buildings, and the ways in which these services were arranged and used, provides a means of understanding the expectations of those living in previous centuries.[82] Defining building defects in the context of early modern 'user requirements' may avoid the 'enormous condescension of posterity' that E.P. Thompson warned us against.[83] Thus, for the purposes of this thesis, 'user requirements' are examined in the context of how they undermined the statutory requirements, as well as those pertaining to the function and performance of buildings. 'User requirements' is therefore not confined to one chapter but is a theme that runs through the building pathology analysis.

A database has been designed and constructed around the *building pathology* definition of building defects.[84] The purpose of the 'Building Pathology Database' is not just to store research material, but also to provide an analytical tool to assess whether the *building pathology* definition of defective housing can assist us in defining and determining the defects in London's early modern housing. There are three main sources for the database, the City's Viewers and Surveyors and the records of property management in the *Historical Gazetteer* of Cheapside.[85]

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[82] Watt, *Building Pathology*, pp. 74-75.

[83] E.P. Thompson, *The Making of the English Working Class* (London, 1963), p.12.

[84] My design of the database was constructed by Peter Cornish, Gatehill Software, Pinner, Middlesex, http://www.gatehillsoftware.com

[85] Derek Keene and Vanessa Harding, *Historical gazetteer of London before the Great Fire* Centre of Metropolitan History, 1987).

The Building Pathology Database is accessible at the following website:

http://earlymodernlondon.info
Username: bpluser
Password: London2015

Building pathology has offered a definition of a building defect but how this may compromise specific health requirements requires consideration.

1.5 The fundamentals of healthful housing

Discourses in *building pathology* have defined a healthful house as one 'serving to promote health of body and mind' from which 'four fundamentals for healthful housing' have been identified:

- The first and most obvious fundamental concerns the environmental conditions of housing needed to prevent or limit the transmission of pathogenic agents. Pathogens, including those associated with enteric and respiratory diseases, are micro-organisms that are normally absent from the body but have mechanisms to invade and cause infection.[86]
- The second fundamental concerns those conditions that must be provided to fulfil the requirements mandated by the limitations of the physiology of humans. In broad terms the study of physiology aims to understand the mechanisms of the body, how the cells, muscles and organs work together and how they interact.[87] In this context, consideration will be given to the possibility that damp, cold, dark and poorly ventilated housing undermined the physiological requirements of the occupants.
- The third fundamental concerns those measures that should be undertaken to prevent injuries incurred by accidents.
- Finally, there are those facilities that should be provided to obtain optimum mental health and well-being. [88]

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[86] Anand and O'Connor, *Pathology*, p.30.

[87] Ibid pp. 11, 12, 13-15, 27, 43,48-50, 55-6, 60, 63-98, 81-21,46-7, 188, and 229-52.

[88] Eric W. Mood, 'Fundamentals of healthful housing: their application in the 21st century' in Burridge and Ormandy (eds.), *Unhealthy Housing*, pp. 306-10. At the date of publishing this work, Mood was professor in the Department of Epidemiology and Public Health at the School of Medicine, Yale

The ‘four fundamentals for healthful housing’ may be considered applicable for early modern housing on the premise stated earlier: the physiology of humans and the function and performance requirements of buildings have not changed significantly since the start of the study period. It is the first two fundamentals, however, which are the focus of this thesis. In contrast, injuries incurred by accidents and mental health are not considered key in determining whether early modern London was healthful or not. Graunt’s findings in early modern London show that death from accidents occurred in much less significant numbers than other causes of death [89] whereas mental illness does not figure at all in his ‘*Chronical distempers’*. This is not to dismiss completely the third and fourth fundamentals for there is some recognition that the failure to satisfy some physiological requirements could have caused accidents,[90] and overcrowding may have produced mental stress.

Modern research has linked the failure of building services with enteric diseases.[91] Building services includes sanitary provisions, water supply, heating, ventilation, lighting and refuse disposal. The study of the building services may assist in understanding the anomalies in the multi-causal account of certain diseases referred to in Chapters 4 and 6. Airborne infections, particularly those related to

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University, Connecticut. He is Chairman of the Committee on Housing and Health of the American Public Health Association and has supervised revision for the housing codes adopted in many cities and states in the USA. He has frequently participated in activities organized by the World Health Organization, p.303.

[89] Harding, ‘Housing and Health’ p.42.

[90] For example, research in Britain has suggested that poor quality heating in buildings can lead to accidents, often resulting in a near fatal outcome. Such accidents are more common in winter because manual dexterity decreases with decreasing temperature. There is also impairment in sensory function, co-ordination and muscle function in the cold, and the impact of severe cold on cerebral function may result in increasing errors when using a building; see K.J. Collins, ‘Cold and heat related illnesses in the Indoor Environment’ in Burridge and Ormandy (eds.), *Unhealthy Housing*, p.137. At the time of writing this account, Collins was a Senior Clinical Lecturer at University College and Middlesex School of Medicine, London University.

[91] Byrne and Keithley ‘Housing and the Health of the community’ p.43. Byrne and Keithly refer specially to the work of Susan Smith, ‘Housing and Health: A Review and Research Agenda,’ Discussion Paper No.27 Glasgow University Centre for Housing Research, 1989, pp. 306-10.

respiratory diseases, are caused by a variety of micro-organisms, and include many common diseases affecting humans. The mechanisms of transmissions of the infectious agents may be by droplet nuclei that harbour micro-organisms, as well as by direct contact. Some caution is required when considering deaths through consumption or tuberculosis in early modern London, but it appears to have been a constant and significant killer in the study period[92] and the droplet is its most common mode of transmission.[93] The study of TB provides an example of the relationship between the spread of pathogens and conditions undermining physiological requirements. Other things being equal, generous internal space which is well ventilated is less likely to facilitate infection, but if resistance is the crucial factor, the well-fed, warm young adult without a childhood history of debilitating minor respiratory infection is best equipped to face the disease.[94] The provision of adequate ventilation and heating are two of the three housing conditions that must be met to satisfy the physiological requirements of the body; the third condition is daylight and again a relationship is recognised here as direct sunlight has some bactericidal effect because of the presence of ultraviolet rays.[95] Thus, lack of heating, ventilation and lighting could lead to physiological disorders by undermining the physical and chemical processes that take place in the body causing harm to the cells, tissues and organ systems.

As noted earlier, M.J. Power suggested further consideration should be given to the possibility that damp in early modern buildings may have represented a greater risk to health than the potential spread of pathogens through overcrowding. This will be explored in depth in the building pathology analysis but it is important at this point to consider the possibility that dampness was widespread in London's buildings and

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[92] Harding states 'Consumption' in the Bills of Mortality was probably not confined to modern pulmonary tuberculosis, but covered a wide range of diseases characterized by cough, including coughing blood, inflammation or ulceration of the lungs, and wasting of the body, see Harding 'Housing and Health' p.38.

[93] Anand and O'Connor, *Pathology*, p.115.

[94] Byrne and Keithley 'Housing and the Health of the community' p.57.

[95] Mood, 'Fundamentals of Healthful Housing', p.329.

formed a link between the first two fundamentals of healthful housing. Singh's extensive research into historic buildings has produced four significant findings:

- The majority of environmental problems in buildings are associated with the lack of maintenance, chronic neglect and building defects leading to water ingress, condensation and dampness in the building fabric.
- The deterioration of materials from which historic buildings are constructed is attributable to changes in the built environment: 'the main environmental parameters affecting decay of materials are water, humidity, temperature and lack of ventilation.
- The causes of deterioration are influenced by the internal building environment, which has a 'varied micro-climate' depending upon the building structure and the envelope of the internal building fabric.
- Buildings affect the health of occupants in many ways, for example, Building-Related illnesses (BRI), Sick Building Syndrome (SBS) and allergy and environmental health problems (AEHP). [96]

Hollis has also observed that 'dampness is inextricably linked with most building deterioration. Water contributes to the oxidation of metals and to circumstances where the propagation of fungal decay or beetle infestation can affect timber. Water is also able to facilitate chemical changes in the components of a building.'[97] Significantly, Hollis concludes that 'although it is essential for life, water presence in building can reduce life expectancy as well as being highly irritating. It can be an agent in the spread of disease [and] the creation of mould…'[98] Identifying the presence of fungus and mould in buildings is key to this study of respiratory illnesses, but equally important is the recognition that dampness has a role in the spread of disease.

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[96] Singh, 'Building pathology and environmental monitoring' p.1.

[97] Hollis, *Surveying Buildings*, p. 405.

[98] Ibid.

The development of fungus is associated with decay in wood[99] and this is considered in detail in chapter 5, not only in the context of the early modern timber-framed buildings, but also where wood was included in the brick-built structures. Fungal spores can give rise to three types of reactions: allergies, infections and toxic effects.[100] In addition to allergic effects, some variety of fungus, for example *Aspergillus fumigatus*, have characteristics which produce severe symptoms caused by direct lung infection.[101] Responses to the inhalation of fugal spores caused by timber decay can range from mild through acute and severe flu-like symptoms to the causation of irreversible changes in lung function after chronic exposure.[102] Some consideration must be given to the possibility that a mistaken diagnosis of influenza was given for an illness produced by the inhalation of fungus in damp early modern buildings. Dobson has observed that the diagnosis of influenza is problematic in the early modern period, but has noted that epidemics were widespread during this period, particularly during the spring of 1658.[103]

The inhalation of fungal spores causes systemic infections that start normally in the lung, sometimes migrating to other organs, including heart, brain and kidneys. The sixteenth-century physician Thomas Phaire was aware of systemic failures following 'The cough in children' with the infection 'descending from the head into the pipes of the longes or breast'[104] but caution must be exercised in attributing such symptoms to the exposure to the spores of fungus. Invasive diseases through the inhalation of fungus are rare in the modern era and usually require both a high

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[99] Ibid. pp. 467-484.

[100] Hunt 'Damp and Mouldy Housing: A Holistic Approach' in Burridge and Ormandy, *Unhealthy Housing*, p.78. At the time of writing this account Sonja Hunt was a partner in Galen Research, Manchester, carrying out research into health measurement and quality of life assessment. She was formerly organizer of a programme evaluating health systems at the Fairborough Dickinson University, USA and then Senior Research Fellow at the University of Edinburgh.

[101] Ibid. p.78.

[102] Ibid. p.79.

[103] Dobson, *Contours of death*, p.508.

[104] Thomas Phaire, *The Boke of Children* (E. & S, Livingstone Ltd, Re-printed 1957), p.43.

concentration of a particular fungus and a very susceptible individual.[105] The conditions required for fungus to develop and its rate of growth in early modern buildings is considered in the building pathology analysis based on information in the reports of the Viewers; this may provide some indication of the potential level of exposure to fungal spores.

Certain fungi produce metabolites that can be toxic. These mycotoxins are contained in the spores of toxigenic fungi and have been established as causes of illness in humans.[106] Reports of human reactions in the modern era have been mainly associated with ingestion rather inhalation and most reports have focused upon food contamination.[107] Food can become contaminated, however, in domestic dwellings and spores may well be swallowed in mucus, especially when in the presence of respiratory problems there is a tendency for breathing to be done through the mouth. There is a long history of fungoid toxins infesting food stored in granaries[108] and Thomas Phaire was conscious of food and drink contamination 'corrupting the stomake and brayne'[109] but he does not stipulate the source. Mycotoxins are readily absorbed through the membranes in the respiratory tract and enter the bloodstream causing damage to other parts of the body. The development of reactions to fungi requires repeated exposure, which can be expected to occur where dwellings are damp. The building pathology analysis will consider contemporary evidence of constant exposure to dampness in buildings and in the context that the severity of the effects may be related to the vulnerability of those who were particularly at risk, such as young children, the elderly and those who were already ill.[110]

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[105] Hunt 'Damp and Mouldy Housing', p.78.

[106] Ibid. p.79.

[107] Ibid.

[108] Porter, *The Greatest Benefit*, p.19.

[109] Phaire, *The Boke of Children* p.43.

[110] D. Strachan and P. Elton, 'Relationship between respiratory morbidity in Children and the home environment' (*Family Practitioner 3, 1986), pp.137-42.* P. McCarthy, D.S. Byrne, S. Harrison and J. Keithley, 'Housing type, housing location and mental health', (*Social Psychiatry, 20,* 1985) pp.125-30. T. Blackman , E. Evason, M, Melaugh and R. Woods 'Housing and Health: a case study of two areas of West Belfast' *Journal of Social Policy,* 1989), pp1-26.

In contrast to fungus, the development of mould is not necessarily related to decay in timber.[111] Damp conditions particularly condensation encourage the growth of mould.[112] The term 'mould' would not appear to be referred to in the study period. Emily Cockayne has given the title 'Mouldy' to one of the Chapters in her book *Hubbub*, but no direct reference to the term is made in the text.[113] Whereas Cockayne suggests that mould existed in damp cold buildings of the early modern period, she mainly considers the subject in the context of decaying foodstuffs. In the building pathology analysis consideration will be given to the possibility of mould existing in damp timber-framed and brick-built buildings of early modern London. Significantly, mould is less likely to be found in conditions of rising and penetrating damp in brick and plaster structures, since the salts that emerge within the moisture tend to inhibit its growth.[114] This would suggest that those occupants living in brick-built buildings in the post-Fire city-centre were less exposed to mould than those living in pre-Fire timber-framed structures, but there is a caveat attached to this conclusion. Condensation contains relatively pure water that is highly conducive to the growth and proliferation of mould spores, which live off wood as well as organic material walls and in cavities, such as plaster, wallpaper and wallpaper paste.[115] Once present, moulds spread easily to carpets, furniture and clothing.[116]

Moulds have long been known to be a source of respiratory allergens and there are cases in the modern era describing reactions so severe that they require hospitalisation.[117] Symptoms have included headaches, swollen and painful joints and breathlessness; X-rays have revealed nodes in lungs.[118] It is to be expected that the elderly would suffer from swollen and painful joints for various reasons but Phaire

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[111] Hollis, *Surveying Buildings*, p.418.

[112] Ibid.

[113] Emily Cockayne, *Hubbub: Filth, Noise & Stench in England* (Yale University Press and New Haven, 2007), Chapter 4.

[114] Hunt 'Damp and Mouldy Housing, p.78.

[115] Ibid.

[116] Hollis, *Surveying Buildings*, p.418.

[117] Hunt 'Damp and Mouldy Housing, p.78.

[118] Ibid.

and his contemporaries did not associate damp and mould with the 'stifnes of limmes' in children but they concluded that the ailment was caused during 'tymes of cold'.[119] Several large-scale investigations in the modern era have indicated that mould may be responsible for respiratory conditions which are the consequence of allergic reactions such as asthma, rhinitis and alveolitis.[120]

The inhalation of fungus and mould, as encouraged by damp housing conditions, represents another form of air-borne ailment but the role of dampness in the spread of disease also extends to pathogens and insects harmful to the human host. Viruses that give rise to infection are more common in damp houses and bacteria also thrive in moist conditions.[121] Research in the modern era has shown that damp housing conditions encourages the dust mite, whose population increases dramatically in 40 per cent or more humidity. Their debris, particularly faecal pellets, act as allergens. The major problems caused by house dust mites are respiratory.[122]

The presence of the dust mite was not referred to specifically in the study period, although John Southall wrote *A Treatise of Bugs* in 1730, in which he observed that bed bugs bite in all seasons. A generic term for bugs appears to be used by the writers of this period with Thomas Tryon referring in 1691 to small worms feeding off the dust, debris and moist substances left in beds[123] and it is therefore possible that the dust mite was active in this study period. To paraphrase Porter, in earlier centuries people no doubt became ill and sometimes died of the various sources of respiratory illnesses described above but it took the outlooks and diagnostic apparatus of modern medicine to create the modern categories of such complaints or to perceive how some respiratory conditions were due to the presence of fungus and mould.[124] The perception of disease in the context of early modern buildings requires closer examination.

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[119] Phaire, *The Boke of Children*, p.31.

[120] Hunt 'Damp and Mouldy Housing, p.79.

[121] Ibid.

[122] Ibid.

[123] These accounts given by Southall and Tryon are quoted in Cockayne, *Hubbub*, pp. 57-8.

[124] Roy Porter, 'What is Disease?' in The *Cambridge History of Medicine*, Roy Porter (ed.) (Cambridge University Press, 2006), pp. 71-102.

1.6 The relationship between defective housing and ill-health

In attempting to establish the relationship between defective housing and ill-health in early modern London, we must first consider the definition of illness in this period. Roy Porter considers that the conception of ill-health, that is, its nature, causes, and meaning is complex and enigmatic. He notes that 'perceptions of sickness have varied greatly over time and place, shaped by diverse circumstances. Different social groups conceptualise illnesses disparately.'[125]

Disease in the early modern era and particularly in connection with housing is often discussed in the context of a biological force in the 'economy of Nature', or as Porter describes it as 'showing humans and microbes locked in a Darwinian struggle for survival.'[126] The difficulty in defining ill-health is that the terms 'disease' and 'ill-health' are often used interchangeably. A modern attempt to differentiate between the two is to define disease as an objective affliction, often triggered by a pathogen, such as a bacillus or a virus, and marked by tell-tale symptoms, such as a rash or raised temperature. Ill-health, on the other hand, denotes something subjective, feelings of malaise or pain. As Porter observes, 'these may be two sides of the same coin but not always.' [127] But does our desire in the modern era to distinguish between disease and ill-health betray historical transformations? The term 'disease' has developed from 'dis-ease'; similarly, malaise from 'mal-aise', that is, ill at ease, a state of discomfort. Thus, Porter sounds a note of caution that within the modern, scientific concept of disease 'lurk softer, more subjective, and historically antecedent connotations.'[128] The emergence of the neutral, scientific concept of 'disease' from earlier ideas of dis-ease, which is akin to our 'illness,' offers an insight into different cultural perceptions and changes over time.[129] Dobson's descriptions of the way patients and practitioners

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[125] Ibid. p.71.

[126] Ibid.

[127] Ibid.

[128] Ibid.

[129] Ibid.

perceived, understood and reacted to the multitude of illness is particularly useful in addressing the problem of defining ill-health in the study period.[130]

Diagnosis in the early modern era is a significant challenge to the validity of this research particularly with reference to the Bills of Mortality. Although parish clerks compiled these weekly and annual returns, they were often assisted by two 'searchers', often elderly women without medical knowledge, whose diagnosis may not have been reliable, but whose enumeration was probably accurate enough.[131] Further consideration will be given to the currency of these searchers in the next Chapter but it is worth noting at this point that even the medical profession of the early modern period had difficulty in diagnosing disease and it has been argued that only plague and smallpox could be recognised with any certainty.[132] The doubts regarding the searchers' diagnosis of diseases have to be put into context, however, with recent medical studies highlighting a great deal of disagreement on diagnosis between doctors in the modern era.[133]

With regard to ill-health, this thesis places a greater emphasis on morbidity and those diseases or *Chronical* distempers leading to premature death. Consideration therefore has to be given to the contribution unhealthy early modern housing made to ill-health and premature death. In relation to morbidity, Chapter 2 considers whether this can be measured in early modern London, for example by demand for medical services, or the detection of clinical symptoms by 'experts.'[134] Margaret Pelling considers that the demand for services was quite high despite Porter observing that Pepys did not often call upon professional medical advice, though he

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[130] Dobson, *Contours of Death*, see her discussion on pp.240-1.

[131] Stephen Inwood, *A History of London* (Macmillan, 1998) p.157.

[132] Maureen Waller, *1700: Scenes from London Life* (London 2000), p.96.

[133] Hunt, 'Damp and mouldy housing' p.69.

[134] See Margaret Pelling in *Health, Disease and Society in Europe,1500-1800*; Roy Porter 'The Patient in England, c. 1660-c.1800, in Andrew Wear (ed.), *Medicine in Society*. On detection in Children, see Thomas Phaire, *The Boke of Children*.

numbered doctors among his friends. 'Prevention was better than cure', and he attended to such matters as diet, exercise, climate, avoiding draughts and damp.[135]

Having received some insight in the way illness was perceived in the study period, the challenge of establishing the extent and the nature of the relationship between defective housing and ill-health needs to be addressed. David Mant has observed that 'research into the relationship between housing and health is not easy. This may seem surprising because the relationship between poor housing and poor health is essentially self evident.'[136] Mant considers that the main problem is that inadequacy of housing is invariably associated with other hardships, such as poor nutrition and hygiene and the curtailment of personal freedom, all of which prejudice health in its widest sense. Mant does offer some optimism and direction to the researcher, however, in stating that 'In most cases, it is neither necessary nor desirable to untangle these threads of disadvantage [and] this is not an excuse for failure to describe and document the extent of the housing problem in Britain, nor the ill-health with which it is associated.' [137] Although Mant has made this statement in the context of modern housing, it is argued this is equally relevant to this research into building-related illnesses in early modern London.

In the early modern context, Harding has observed that 'comparatively few parish registers offer information on the cause of death, and none does so for long periods, so while very local studies may be possible, comparisons over time and space are difficult. So far we have had to proceed more by inference and hypothesis, using a range of qualitative as well as quantitative sources.'[138] Dobson considers that the disentangling of causal mechanisms in the external environment in south-east England is equally problematic.[139] Disentangling causal mechanisms is further complicated by the probable time lag between living in poor housing and some of the health implications. With regard to early modern London, Harding considers that

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[135] Margaret Pelling, *The Common Lot, Sickness, Medical Occupations, and the Urban Poor in Early Modern England* (London and New York, 1998); Roy Porter, *The Greatest Benefit*, p.35.

[136] Mant, 'Understanding the problems', p.3.

[137] Ibid.

[138] Harding, 'Housing and Health', pp. 33-34.

[139] Dobson, *Contours of Death* pp. 493-539.

'looking for a connection between particular houses or areas of housing and particular health outcomes appears to require a specificity of information that in general is not available, as well as to assume that most individuals lived long enough in one property for its effect on their health to be significant.'[140] Such challenges to housing and health research are addressed in the next Chapter. Amongst other matters, consideration will be given to whether the desire to 'untangle' the various 'threads' of ill-health has hampered the investigation into building-related illness. Chapter 2 will develop the argument that poor nutrition, hygiene and curtailment of personal freedom are all part of housing. This argument is based on a concept that has been developed by statisticians in many other areas of quantitative research, known as 'partialling-out.' For example, in referring to the hardships co-existing with defective housing, as quoted earlier by Mant, permanent exposure to a cold, damp building causes the body to over-work to compensate for this unhealthy environment and the body burns up energy and the nutritional status is reduced, thereby exposing the person to all manner of diseases. 'Partialling-out' recognises that the issues of defective housing are interconnected with many other hardships and do not need to be separated, however the effects can be weighted in an attempt to advance our research into building-related illnesses; therefore a more holistic approach is required and by definition this is what *building pathology* offers. [141]

The holistic approach to research into building-related illnesses by Roger Burridge and David Ormandy has augmented the development of *building pathology*. In their book *Unhealthy Housing, Research, Remedies and Reform,* Burridge and Ormandy sought the views of various eminent contributors from a wide range of

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[140] Harding, 'Housing and Health', p.24.

[141] Partialling-out is a technique that is based on both analysis of variance (ANOVA) and linear regression. This technique is called *analysis of covariance* (ANCOVA). A simple ANCOVA demonstrates whether particular groups differ on a dependent variable, while partialling out the effects of another variable, called the *covariate*. A covariate is a variable that has a linear relationship with the dependent variable. Statisticians assist analysis by removing (partialling out) the effects of a variable. See Daniel Borcard *et al* 'Partialling out the Spatial Component of Ecological Variation' in *Ecology,* published by the Ecological Society of America, Volume 73, Issue 3 (June, 1992), 1045-1055, http://www.jstor.org/jornal/esa.html. Accessed 23 February, 2011.

disciplines and backgrounds.[142] The contributors, including David Mant and Eric Mood, were practising doctors, medical scientists, epidemiologists, academics, architects, lawyers, housing administrators, environmental health officers and statisticians. The object of the *Unhealthy Housing* was to present an analysis of the research into the health implications of housing and the significance for legal regulation of housing conditions. This was achieved by presenting short papers from the contributors together with an overview that related the different disciplines to the health of occupiers. Published in 1993, the work of Burridge, Ormandy *et al* has apparently withstood the test of time, with no apparent requirement to update their findings.[143] The interdisciplinary approach described by Burridge and Ormandy as 'the pathology of housing related illness' exposes the relationship between poor housing and ill-health and will be engaged in this study of early modern London.

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[142] Burridge and Ormandy (eds.), *Unhealthy Housing.* At the date of publication, Burridge and Ormandy were based at the University of Warwick. Burridge is a barrister and lecturer in the School of Law and has conducted research into the regulation of dilapidated housing. Ormandy is an environmental health consultant and Research Fellow at the Legal Research Institute, at the university and is editor of *Housing Law Update* and co-author with Burridge of *Environmental Health Standard in Housing.*

[143] A personal communication with David Ormandy, at the University of Warwick, by email on 6 October 2008.

Chapter 2
Addressing the Problems of Housing and Health Research

The aim of this Chapter is to identify the approach, parameters and nature of health and housing research in early modern London. The first task in considering the approach involves addressing a recurrent question posed by historians and modern medical practitioners in this area of research: should the state of health of a city be viewed from the perspective of individual attributes or from that of the community?

2.1 The Approach: public health or private illness

It was noted in the opening Chapter that historical evidence suggests the improvement in health of urban populations since the late Victorian period was due to a collective effort in addressing the problems of public or community health; this was not, however, a Victorian initiative. The physician, economist and scientist William Petty (1623-1687) was one of many writers on the subject of community health in the early modern period. Petty was conscious of the importance of a healthy population as a factor in national prosperity and power. Repeatedly, Petty urged the collection of numerical data on population, education, diseases, revenue and many other related topics.[1] He argued that the analysis of such data could throw light on matters of national interest and policy, and to this end he employed mathematical calculations wherever possible. This new field of endeavour was given the name 'political arithmetic.'[2] This development was not without antecedents. The importance of statistical knowledge with regard to cities had been recognised in the Italian Renaissance period, notably in Florence and Venice but had not been developed into a method for the analysis of health problems.[3] While Petty recognised the importance of a quantitative study of health problems and suggested many topics for investigation, it was his contemporary John Graunt who made the first solid contribution to this field in 1662.

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[1] Sir William Petty, *A Treatise of Taxes and Contributions*, 1662 (Early English Books On-line, Bib name / number: Wing / P1938), pp.4-31.

[2] Rosen, *A History of Public Health* (The Johns Hopkins University Press, 1993) p.87.

[3] Ibid.

As noted in Chapter 1, Graunt's figures were obtained from his analysis of the Bills of Mortality and showed the number of deaths in London during the preceding third of a century. Graunt declared 'There is much pleasure in deducing so many obtuse and unexpected inferences out of the despised Bills of Mortality'.[4] Thus, Graunt confirmed that his approach to interpreting the Bills was by inductive reasoning. Through this process he deduced the regularity of certain social and vital phenomena and brought to light a number of important facts. On the population and housing of London Graunt noted that between 1603 and 1644 burials (363,935) exceeded christenings (330,747) and he concluded:

> From this single Observation it will follow, that London should have decreased in its People; the contrary whereof we see by its daily increases of Buildings upon new Foundations, and by the turning of great Palacious Houses into small Tenements. It is therefore certain, that London is supplied with People from out of the Country, whereby not only to supply the overplus differences of Burials above mentioned, but likewise its inhabitants according to the said increasing in housing.[5]

It is argued here that Graunt's approach in analysing aggregate data, as a means to determine the healthfulness of the built environment, was the correct one at the time and remains so today. Despite the historical evidence vindicating the aggregate approach, in 1984 the editors of the *Journal of Epidemiology and Community Health* found it necessary to remind readers and contributors that community health in the modern era meant something more than the study of the health states of individuals in a community; they expressed considerable concern about the decline in work by doctors on the issues of the health of the community as a whole.[6] The importance of this observation pertaining to the modern era is crucial to the validity of the approach to investigating building-related illnesses in the early modern period using aggregate data. If arguments are to be put forward for moving away from the notions of 'health' and 'illness' as solely individual attributes, consideration must first be given to whether it is appropriate to talk about the 'health' of London's early modern community, and secondly, justify the approach of 'social

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[4] Graunt, *Natural and Political Observations,* p. 97

[5] Ibid. pp. 57-8.

[6] Byrne and Keithley, 'Housing and the Health of the Community ' p.41.

epidemiology'. These matters are addressed within the context of discourses in *building pathology*.

2.1.i The health of the community

Some modern writers on epidemiology have recognised conflicts in the approach to building related-illnesses, with the response to housing inadequacies emphasising private initiative. Among these writers is S.S. Blume, who argues that epidemiology in the modern era has become subordinate to a clinical, individualistic, medical perspective. Although epidemiologists still study populations, Blume has observed that their ultimate concern is with the health or ill-health of individuals and with how far linkages (in this case, between health and housing) can be confirmed by, or are plausible in the light of clinical and laboratory studies and biomedical theories.[7] For Blume, 'epidemiology is at root no less individualistic than are the basic biomedical sciences with which it is linked in a common endeavour' and 'epidemiologists see their field as serving to complement the insights gained from clinical and laboratory study in the understanding of disease aetiologies.'[8] Blume quotes Susser to the effect that: 'despite the epidemiologist's insistence on studying populations, his ultimate concern is with health and disease, and death as it occurs in individuals.'[9] It is a matter for debate whether this was the aim of Petty and Graunt. The key question at this point, however, is whether this individualistic emphasis is necessary and whether it helps or hinders our understanding of relationships between housing and health.

Byrne and Keithley have challenged the merit of the approach in modern research that seeks to attribute individual ill-health to poor housing conditions because of its emphasis upon individual pathology.[10] Modern literature pertaining to individual pathology is based on data which is limited and extremely difficult to 'prove' not only because of the presence of so many other intervening factors, but

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[7] S.S. Blume, 'Explanation and social policy' (*Journal of Social Policy, 11,* 1982) pp.7-32.

[8] Ibid. p.26 and 30.

[9] I. Susser, *Causal thinking in the health sciences* (Open University Press, Milton Keynes, 1973) quoted in Blume, ' Explanation and social policy' p.30.

[10] Byrne and Keithley, 'Housing and the Health of the Community', Chapter 3.

also because laboratory and other studies have often failed to demonstrate clear relationships in the 'positivist' sense. This is explored later in the Chapter. Taking into account these modern discourses in epidemiology, consideration must be given to the merit of those historians looking beyond the aggregate data provided by the Bills of Mortality. The historians Peter Razzell and Christine Spence consider the currency of the Bills to be arbitrary. They note that the reliability of this source has also been subject to much criticism from others, including Dorothy George.[11] Razzell and Spence argue that much modern demographic research focuses on individual families through a process known as 'family reconstitution', enabling a more detailed study of a range of variables. Chris Galley considers that aggregate data and family reconstitution are two techniques that are not mutually exclusive, however, the latter is more difficult to employ in an urban environment.[12] Galley has observed that 'family reconstitution' has been used successfully within small early modern market towns such as Banbury and Gainsborough, that were entirely contained within a single parish; any additional problems, compared with rural reconstitutions, only relate to scale. Reconstitution requires that the register is of the highest quality, and since most cities were sub-divided into many small parishes, it is unlikely that a complete set of registers from a large provincial city will have survived that is both complete and of sufficient quality. All the major early modern cities and towns were split into large numbers of parishes: London had over 100, Norwich 33, Bristol 18 and Ipswich 13.[13]

The findings put forward by Petty and Graunt offered a political and economic incentive for national or local government intervention into the built environment, even if it was not expressed from a moral perspective. Petty saw control of communicable disease and the saving of infant life would contribute most to preventing the impairment of the population.[14] Despite their great potential, the ideas

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[11] Peter Razzell and Christine Spence, 'The History of Infant, Child and Adult Mortality in London, 1550-1850'(London *Journal, Vol. 32. No.3,* November 2007), p.272 n.10. See also Dorothy George, *London Life,* pp.35-6.

[12] Chris Galley, *The Demography of Early Modern Towns*, pp. 154-5.

[13] Ibid.

[14] Rosen, *A History of Public Health,* p.91

of these eminent thinkers had no immediate tangible results in terms of utilising conclusions from aggregate data to improve the health at the level of the community. Porter and Risse argue that most medical activities up to and including this study period had followed the classical models of Hippocrates and Galen, that is of private health care restricted to the individual demands of sick persons usually belonging to the upper social strata.[15] This requires further consideration, particularly if the background levels of mortality, including Graunt's *Chronical* distempers, are to provide a more reliable indicator of the healthfulness of early modern London.

Writing in the fifth century B.C., the father of modern medicine, Hippocrates, considered that the relationship between health and the environment was crucial for 'whosoever wishes to investigate medicine properly.'[16] Hippocrates wrote a treatise on 'Airs, Water, and Places' in which he examined the role of external environmental conditions in the cause of disease in the individual as well as epidemics in the community. Hippocrates attempted to look beyond the individual patient and offer some sensible advice about housing and town planning construction, along with drinking water and other factors that can influence health.[17] Galen (c129-210 AD) sought to perfect the work of Hippocrates by fusing his clinical knowledge with the theoretical. This is illustrated in Galen's writings on fevers, a group of diseases figuring quite prominently in the Bills of Mortality.[18] It was thought that fevers might result from either an excess of yellow bile, black bile or phlegm, or an excess of blood. Surplus humours might accumulate in some bodily part where they could cause putrefaction and excess heat or fever. To remove such superfluities and restore humoral balance, Galen advocated energetic blood-letting; this was in contrast to the earlier Hippocratic treatment of fevers by starvation.[19]

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[15] Roy Porter 'The patient in England, c.1660-c.1800' and Guenter Risse 'Medicine in the age of Enlightenment' both in Wear (ed.), *Medicine in Society*.

[16] Francis Adams, *The Translation of Airs, Waters and Places,* by Hippocrates, http:2//classics.mit.edu/Hippocrates/airwatpl.1.html. Accessed 3rd March 2006.

[17] Ibid.

[18] Galen, *The art of Medicine* in *Galen, Selected Works,* ed. P.N. Singer (Oxford and New York University Press, 1997), pp.345-8.

[19] Porter, *The Greatest Benefit,* p.75.

It is likely that the professional physicians read these classical texts, whilst others would have relied upon contemporary interpretations and evolving remedies. The sixteenth-century physician Thomas Phaire would have been amongst the profession class of physicians. In his *The Boke of Children*, published in1545, Phaire refers to the diagnostic methodology of Galen, 'the prince of this arte.'[20] Phaire advised that through the Galenic methodology of observation and logic, the experienced practitioner would determine that a child 'with a great shaking and afterward hote, whether it be cotidian or tercian,' was clearly suffering from a fever. Phaire's remedy was less drastic than those specified in the classical texts, where he recommended 'it shal be synguler good to geue it in drynke, the blacke seedes of peony made in fine pouder, searced & myngled with a little suger.'[21] Phaire's book was the first text on paediatrics ever written by an Englishman and is of great value to this thesis in consideration of the high morbidity and mortality of infants throughout the study period.

Whereas Phaire appears to epitomise the practitioner referred to by Porter and Risse insofar as he focused on the individual, he was keen to spread health information through his *Boke* beyond the privileged few. The work of Dobson and Wear suggests that other early modern physicians became increasingly concerned with the need to look beyond the individual patient and towards the environment and consideration of the cause of disease. [22] For example, London had low-lying land around the Thames and its tributaries and the physician Tobias Venner wrote in 1628 at length on the relationship between health and such locations:

> Therefore he that desireth to live a long a healthy life, must dwell in an eminent and champion country, or at least, in a place that is free from muddy and waterish impurities: for it is impossible, that a man should live long and healthily in a place, where the spirits are with impure ayre daily affected.[23]

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[20] Phaire, *The Boke of Children*, pp.13-14.

[21] Ibid. pp.58-9.

[22] Dobson, *Contours of death*, p.10 and Wear (ed.), *Medicine in Society*, pp. 119-148.

[23] Tobias Venner, *Via Recta ad Vitam Longam* (London, 1628), p.8, quoted in Wear (ed.), *Medicine in Society*, p.133.

Marshy air in general was considered to be the cause of nearly all 'the diseases of the braine and sinews, as Crampes, Palsies etc. with paines in the joynts…'[24] It is possible that this applied to the flat marshy areas around the Thames at Rotherhithe, Pimlico, the Isle of Dogs and Southwark.[25] Evelyn advised his King to plant sweet smelling trees in the 'depressed and Marshy Grounds about the Town.'[26] Dodson has observed that malaria transmitted by Anopheles Atroparvus probably extended along the Thames into some marshy districts of London and Southwark, and the term 'Borough Ague' was used at Guy's Hospital to describe the fever prevalent in Southwark Marshland.[27] Pelling also gives an account of the presence of malaria in Southwark, where an anonymous alehouse keeper of the early eighteenth century took to selling an ague cure in the form of ale brewed with Cinchona Bark.[28] Although this is not a disease relating directly to the quality of the building fabric, it may also be considered a part of housing, with building taking place in poor 'natural' environmental areas.

The work of the English clinician, Thomas Sydenham (1624-89) and his conception of disease was enormously influential and assisted in the revival of Hippocratic ideas. Sydenham emphasised the importance of observation and the accumulation of data in medical research. Ironically, it would appear that it was France and not his native country where significant use was made of his research; Brockliss and Jones describe how his work was incorporated into French 'environmental engineering' or community health programmes.[29] Contrary to established opinion, Sydenham argued that diseases were specific entities and were not the product of humoral imbalance in the individual patient:

> It is necessary that all Diseases should be reduced to certain and definite Species, with the same diligence we see it is done by Botonick Writers in

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[24] Ibid.

[25] These areas are identified by Sheppard, *London: A History* (BCA, 1999), p.15.

[26] Evelyn, *Fumifigium, The Smoake of London,* (Oxford, reprinted 1930), p.3.

[27] Dobson, *Contours of Death*, p.321.

[28] Pelling, *The Common Lot*, p.57.

[29] Laurence Brockliss and Colin Jones, *The Medical World of Early Modern France* (Oxford University Press, 2002), p.395.

> their Herbals. For there are found Diseases that are reduced under the same Genus and Name, and as to some Symptoms, are like one another; yet they are different in their Natures, and require a different cure.[30]

According to Sydenham a doctor could only derive a true picture of a disease by building up a profile of its characteristic history from the study of a large number of individual case histories. His methodology involved measuring the incidence of epidemic diseases from year to year and correlating these factors with the weather. This required the collection and collation of a large amount of data in order to establish the characteristic profile of a particular condition. In the late seventeenth century he carefully documented the pestiferous airs and epidemic constitutions of London and its associations with changing weather conditions and seasonal patterns.[31]

Other contemporary physicians and Fellows of the Royal Society, men like Wren, Hooke, Locke, Boyle and their followers, began to develop the potential of practical weather recording instruments, such as the rain gauge, thermometers, barometers, wind recorder and hygroscope as a way of producing information with which to explore the disease-weather relationship. It would appear that the focus was very much on the external environment, however, Sydenham did encourage a broad approach for his research and fostered the art of diagnosis by Hippocratic physicians. This involved creating a profile of the patient's way of life, habitation, work and dietary habits; thus, aspects of living within a house would have been considered. The build-up of such a profile could be seen as an early version of the definition of human pathology given in the opening Chapter. This profiling was achieved partly by asking questions, and partly by the use of trained senses:

> When you examine the patient, inquire into all particulars; first how the head is…then examine the hypochondrium and sides be free from pain, for…if there is pain in the side, and along with the pain either cough, tormina or bellyache, the bowels should be opened with clysters…The Physcian should ascertain whether the patient be apte to faint when he is raised up, and whether his breathing is free.[32]

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[30] Peter Elmer and Ole Peter Grell (eds.) *Health, disease and society in Europe 1500-1800* (Manchester University Press, 2004), p.290.

[31] Ibid.

[32] An unknown source cited in Porter, *The Greatest Benefit,* p.61.

Hippocratic physicians prided themselves on their clinical acuity, being quick to pick up tell-tale symptoms, as with the *facies hippocratica*, the facial look of the dying: 'a protrusive nose, hollow eyes, sunken temples, cold ears that are drawn in with the lobes turned outward, the forehead's skin rough and tense like parchment, and the whole face greenish or black or blue-grey or leaden.'[33]

In fulfilment of the physician's diagnostic rite called 'taking the history', the practitioner would further conduct some physical scrutiny, mainly by the unaided eye, paying attention to inflammation, rashes, spots, signs of swelling and so forth. He would also take the pulse, making a qualitative assessment, such as observing whether it was languid or racing, regular or erratic. The physician would also listen to coughs, wheezing and eructation, and use his sense of smell for any odour of putrefaction.[34] Thus, it is clear that Hippocratic physicians cultivated diagnostic skills, enhanced by the interrogation of the patient but Porter considers that the physical examination was generally perfunctory.[35]

It is significant that Sydenham's *The Whole Works* not only dealt with 'Acute' diseases, such as epidemics but also *Chronical* Diseases. Mary Dobson has observed that, unlike many of his contemporaries and successors, Sydenham made few references to statistical data from the Bills of Mortality.[36] The reason for this is a matter of conjecture but it is possible that Sydenham had concerns over the reliability of the Bills of Mortality. As noted in Chapter 1, although these weekly and annual returns were compiled by parish clerks they were often assisted by two 'searchers', often elderly women without medical knowledge. Graunt explained the process:

> When anyone dies then, either by the tolling, or ringing of the bell, or by bespeaking of a grave of the sexton, the same is known to the searchers, corresponding with the said sexton. The searchers hereupon (who are antient matrons, sworn to their office) repair to the place where the dead corps lies, and by view of the same, and by other enquiries, they examine by what

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[33] Ibid.

[34] Roy Porter *Bodies Politic: Disease, Death and Doctors in Britain, 1650-1900* (London 2001), p.89

[35] Ibid.

[36] Dobson, *Contours of Death*, p.19

> disease or casualty the corps died. Hereupon they make their report to the parish clerk.[37]

Graunt expressed misgivings about the reliability of 'the old searchers [who] after the mist of ale, and the bribe of a two-groat[38] fee, instead of one, given them, cannot tell whether this emaciation or leanness were from phthisis[39] or from an hectic fever, atrophy, &c.'[40] John Bell, Clerk to the Company of Parish Clerks of London, defended the searchers a few years later in his *Londons Remembrancer* (1665):

> True and undeniable it is, That the *Searchers* are generally ancient women, and I think most fit for that office: But I am sure they are chosen by some of the eminentest men of the Parish to which they stand related; and if any of the choosers should speak against their abilities, they should disparage their own Judgements. And after such Choice they are examined touching their sufficiency, sworn to that Office by the Dean of the Arches, or some Justices of the Peace, as the cause shall require.[41]

Forbes suggests that the searchers no doubt did on occasion accept a bribe, probably most often to conceal a case of plague because of the quarantine and other restrictions which would be imposed on others in the house if this disease was reported.[42] Nevertheless, our attention is drawn to Thomas Birch and his discussions on the Bills of Mortality in 1759:

> The low capacity of the person usually chosen to this office [searcher] has been made an objection to the truth and justness of the bills. But with regard to natural deaths, there seems no capacity in these searchers than that of relating what they hear. For the wisest person in the parish would be able to find out very few distempers from a bare inspection of the dead body, and could only bring back an account, as the family and friends of the deceased would be pleases to give.[43]

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[37] Quoted in Thomas Roger Forbes *Chronicle from Aldgate: Life and Death in Shakespeare's London* (New Haven and London Yale University Press, 1971), p.96.

[38] Ibid p.97.

[39] Ibid. This is a wasting disease.

[40] Ibid.

[41] Quoted in Forbes *Chronicle from Aldgate*,' p.98. According to Forbes the judge of the Court of Arches, had jurisdiction over certain London parishes under the Archbishop of Canterbury.

[42] Ibid. p.99.

[43] Thomas Birch (ed.) *A Collection of the Yearly Bills of Mortality, from 1657 to 1758 inclusive …London* quoted in Forbes *Chronicle from Aldgate* p.99

As noted in the preceding Chapter, the medical profession of the early modern period had difficulty in diagnosing disease with only plague and smallpox recognised with any certainty.[44] Such was the confidence in diagnosing smallpox and measles that in 1545, Phaire stated 'The signes of them both are so manifest to sight, that they need no farther declaration' [for they were so] 'comon & familier' with the measles 'engendered of the inflamacion of the bloud, and the small pockes of the inflammacion of bloude myngled with cholere.'[45]

The limitations and doubts regarding the accuracy in diagnosing diseases in early modern London have to be put into context, with Sonja Hunt observing a great deal of disagreement on diagnosis between doctors in the modern era. Hunt provides examples of diagnostic issues concerning asthma and bronchitis cases, which are two diseases of particular interest in this 'critical appraisal'. Some doctors have preferences in diagnoses and diagnostic categories are subject to 'fad and fashions.' Reliance on diagnostic instrumentation, such as measures of respiratory function or other indicators of physiological function is misplaced unless their application can be rigidly controlled with respect to timing, place and error observation.[46] As noted earlier in this Chapter, such arbitrariness of diagnosis in the modern era has led to the concerns over the validity of individual pathology.[47]

David Mant has highlighted three significant issues in case-centred studies: first, there are problems concerning case definition and ascertainment; second, are the inconsistencies in how the data on exposure is collected; finally, is the difficulty of 'confounding'.[48] The latter requires explanation. A 'confounder' is a factor that influences both exposure to a particular hazard and (independently) the likelihood of an adverse health event. For example, the method of early modern heating may well be a confounder in examining the relationship between dampness and respiratory

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[44] Waller, *1700*, p.96 ; with regard to smallpox, see John Landers, *Death and the Metropolis: Studies in the Demographic History of London, 1670-1830* (Cambridge, 1993), p.203.

[45] Phaire, The *Boke of Children*, p.56.

[46] Hunt, 'Damp and Mouldy Housing' pp.69-70.

[47] Byrne and Keithley, 'Housing and the Health of the Community.'

[48] Mant, 'Understanding the problems' pp. 8-9

disease: the use of open fires would have had a major effect on the relative humidity of the dwelling, while at the same time combustion products, such as the burning of sea coal, may well have exerted an independent effect on respiratory function. This is considered in detail in Chapter 6.

The deductive reasoning of Graunt recognised the issue of confounding long before the term was coined. He observed the demand for heating from London's expanding population. Graunt considered that the rapid growth of the population 'partly' contributed generally to the *Chronical* diseases, including those of a respiratory nature, whereas a significant factor was the burning of Sea coal, causing 'unpleasantness' and 'suffocation.'[49] Coal burning increased as the population grew, and the availability and relative cheapness of coal brought via the sea and Thames was a factor that allowed London to grow way beyond local sources of fuel.[50] It therefore follows that any diagnosis of individual case studies from early modern sources is even more problematic, particularly as it is exaggerated by the passage of time. Thus, for the purposes of this investigation, the findings of early modern clinicians cannot be seen as supplementing the proposed epidemiological approach.

2.1.ii Justifying the approach of social epidemiology

This sub-section may appear at first an epistemological diversion, but the argument set out below is intended to explain the approach and the concept of 'social epidemiology'. Byrne and Keithley argue that it is necessary to understand that a 'realist' rather than a 'positivist' epistemology informs their approach to 'social epidemiology'.[51] Epistemology, or the philosophy of knowledge, can be defined in this context as the way in which the science of building and human physiology 'knows what is real.' It is concerned with the philosophical justification of our methods of understanding the phenomena we investigate. The dominant

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[49] Graunt, *Natural and Political Observations*, p. 94-5.

[50] Sheppard, *London: A History* p.104.

[51] Byrne and Keithley, 'Housing and the Health of the Community' p.56. In the philosophical context, this is the doctrine that abstract concepts have an objective existence. In other words concepts existing in thought or theory, rather than matter or practice have an external or outward existence. In contrast 'Positivism', is a philosophical system recognising only facts and observable phenomena.

epistemological position in biomedical science has, in modern times, been 'positivist'. There is not space here for a developed account of the differences between positivism and realism[52] but one difference is of such importance, however, that it does merit elaboration. In the 'positivist' framework, the emphasis in understanding is on single causes with associated individual effects. The cause of an infectious disease, for example, is seen as a micro-organism and is best explained here by referring to Bradbury's classic 1933 investigation of the causes of Tuberculosis.[53]

Bradbury acknowledged this positivist principle: 'In one sense there is only one cause of Tuberculosis, the TB bacillus.'[54] His analysis, however, places him in the camp of a 'realist' (before the term was coined in this context) by saying that 'exposure to the bacillus was necessary for the development of clinical TB in a patient, but was not sufficient.'[55] Many who were exposed did not develop the disease. Bradbury attributed this to improved housing, better nutrition and not being Irish. Thus, the determinants of a causal system are identified; the last determinant is significant because what Bradbury was asserting was that those of Irish descent had one generation less of exposure to the conditions of urban life and endemic tuberculosis.[56]

The identification of causal systems of diseases justifies this approach to investigating the state of health of early modern London in terms of the community rather than the flawed perspective of individual attributes. The account given by Bradbury of the contraction of clinical tuberculosis did depend on exposure, but in an urban industrial era when the disease was endemic, almost everyone was exposed. The likelihood of developing the disease was reduced by better genetic resistance, the

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[52] See R. Keat 'Positivism and statistics in social science', in J. Irvine *et al* (eds.) *Demystifying Social Statistics* (Pluto, London, 1979).

[53] For this and what follows, see F.C.S Bradbury, *Causal Factors in Tuberculosis*, National Association for the Prevention of TB (London, 1933), re-printed in Br Med J. 1947 June 28; 1(4512): 944–945.

[54] Ibid.

[55] Ibid.

[56] Ibid.

consequence of winnowing over generations, such as the case of native Londoners, and better pheno-typical resistance produced by the consequence of better feeding and improved housing conditions.[57] The variation in such determinants is a theme that is discussed in the next section to this Chapter together with the construction of a framework for assessing fluctuations in respiratory and enteric diseases in early modern London.

As noted in the opening Chapter, it is now widely accepted that the reductions in mortality and morbidity, especially at young ages in Britain and similar societies over the past century came too early to owe much to advances in modern, individualistic curative medicine. This investigation into community or aggregate health will not only be viewed from levels of mortality pertaining to infectious diseases for *building pathology* studies have shown that poor environmental conditions have been directly or indirectly associated with a high incidence of diseases which are not infectious. These studies suggest that these non-infectious diseases are more likely to be associated with excess morbidity and premature mortality in middle age and beyond rather than among younger adults and children. Graunt's *Chronical* distempers also included non-infectious diseases.

Vanessa Harding notes that despite the problems with translating the 'Diseases and causalities' identified in the Bills into modern diagnoses, and the fact that many 'casualties' describe symptoms or coincidental phenomena rather than causes, 'it is possible to use the Bills to generalise about London's mortality profile.'[58] Three major components have been identified from this profile: infant mortality, epidemic mortality including plague, and endemic mortality including 'aged' deaths.[59] Galley also lends support to the value of the Bills in this research. Compared with other early modern towns, the Bills of Mortality for London were the most impressive as they have been used to provide a wide ranging measurement of mortality change in the capital and their accuracy is testified by the derivation of annual infant mortality rates consistent with those from the early years of Civil

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[57] Byrne and Keithley, 'Housing and the Health of the Community' p.57.

[58] Harding,'Housing and Health', p.29.

[59] Ibid.

Registration.[60] Graunt's work is particularly significant in that it contains the beginnings of statistical methods of analysis, not least in asking key questions to determine the validity of his research that also set limitations on his interpretation. Significantly, Graunt recognised that the accuracy of mathematical deductions from data must inevitably be limited in one way or another by the adequacy and precision of the observations themselves.

The work of Petty and Graunt appears to have predicted the arguments put forward in *building pathology* studies: there is greater value in assessing the health of a city's population through the monitoring of the health of communities, collectively based and spatially ordered, rather than focusing on individual-centred system of health care. By way of illustration, Byrne and Keithley refer to an example of how in the 1930s the concept of 'aggregate health' was taken to justify action to improve housing conditions. Evidence of the Medical Officer of Health for Tynemouth County Borough was given to the public enquiry dealing with the Clive Street Clearance Area, held in February 1933.[61] The evidence provided was aggregate and dealt with a specific residential area; it was not 'individualistic.' If the Medical Officer of Health had asserted that the housing conditions of Barnes Close caused an individual case of tuberculosis, then he would have been guilty of an 'ecological fallacy', which has been defined as 'shorthand for…the use of aggregate data for inference to individuals.'[62] Subject to subsequent discussion about 'causality', the Medical Officer was on much safer ground when he said that the poor housing conditions caused the higher rate of tuberculosis in the area and went on to prescribe clearance as an effective treatment for the health of the residents in the area as a whole.

Although it may be perfectly possible to relate housing conditions to the health of an individual resident in a particular dwelling in the twenty first century, Byrne and Keithley argue that it is more important to conceptualise the impact of differential housing conditions on the aggregate health of whole communities; this is the basis of 'social epidemiology' introduced in Chapter 1. This approach assists our

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[60] Galley, *The Demography of Early Modern Towns,* p.154.

[61] Byrne and Keithley, 'Housing and the Health' pp. 51-52.

[62] J.L. Hammond 'Two sources of error in ecological correlations', (1973), quoted in Byrne and Keithley, 'Housing and the Health', p.53. This concept is explored in more detail in Chapter 2.

investigation into the relationship with poor housing and ill-health in early modern London, because as Justin Champion has observed, to explore the relationship between disease and the environment is a fairly straight forward procedure given the various computer software packages now available. Using some of the lay-friendly relational database programmes it is still possible to relate deaths to places. [63] The next stage is to identify specific parameters if we are to consider dwellings as a significant variable in the morbidity and mortality profile of early modern London. George Rosen, in his monumental work *A History of Public Health*, considers that such health aspects of the home are manifold and still relatively unexplored.[64]

2.2 Identifying the parameters pertaining to the health hazards of housing.

The required parameters are those that can enable us to investigate the exposure of the occupants of housing to enteric and respiratory diseases. John Landers, in his analysis of *Death and the metropolis*,[65] identifies the built environment as an important factor in the mortality profile of London. Despite this, however, relatively little detail is given to the internal environment of the house and how it interacted with the external surroundings. Landers focuses on the built environment as a whole but his findings can be projected into the interior by using the tools of *building pathology*. Landers has built a model which comprises 'proximate determinants', two of which relate to the built environment, namely 'conduction' and 'retention'.[66] The former refers to the density of a matrix of potential pathways for infection offered by the environment, whether such infections are air-, water- and food- borne, or spread by animal vectors. 'Retention' reflects the capacity of the environment to retain pathogens. It is proposed to extend the proximate determinants 'conduction' and 'retention' to include non-infectious diseases.

The 'conduction' of airborne disease will be assessed in Chapter 4 in the context of comparing the influence of restricted space in different areas of London. In

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[63] Champion, 'Epidemics and the built environment in 1665' http://www.history.ac.uk/cmh.epichamp.html, p.1.

[64] Rosen, *A History of Public Health*, p.465.

[65] Landers, *Death and the Metropolis*, p.87.

[66] Ibid. p.13.

the 97 parishes within the walls, strong demand for accommodation close to the city centre meant that land values were high and there were significant constraints on space. Although the population density was high, the buildings were not necessarily overcrowded as the soaring property values encouraged building upwards and extending houses backwards over yards.[67] The 'conduction' of air- and water-borne diseases (enteric) may have been significant in such houses that were likely to have their own privies and piped water supply respectively. Due to limited space within the grounds of the buildings, privies were either located near to or within the dwellings. Chapter 6 will consider any potential sources of enteric diseases through the examination of the way privies functioned, performed and were used. A variety of internal environmental conditions may have existed in the city centre on account of the presence of smaller houses in the lanes and alleys that housed artisans and craftsmen.

The 'conduction' of airborne disease within the houses in the sixteen inner suburbs is compared with those of the city centre and outer suburbs. Partly settled in the Middle Ages, the main streets in these areas were lined with relatively good quality houses but they were backed by a spread of newer and poorer housing.[68] The capital's rapid growth in population was concentrated in these suburbs between the mid-sixteenth and mid-seventeenth centuries and the building pattern was constrained by the lines of the major streets and the existing framework of freehold plots. As a result, standing houses were sub-divided.[69] The 'conduction' of airborne infection produced by these internal environments was potentially greater in housing where rooms were multi-functional combining living, sleeping and possibly cooking. The potential for the interaction between the external and internal environments has greater significance with these house types due to the casual systems linking disease brought into the house by shared drinking and sanitation provisions. Paradoxically such interaction between the external and internal environment would have existed in some of the fashionable West End developments; the houses in Covent Garden were

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[67] Harding *et al*, *People in Place*, p.27.

[68] Harding 'Housing and Health' p.36.

[69] Ibid.

initially built without independent water supplies.[70] Such situations highlight a conceptual challenge in connecting building-related illnesses to specific social groups and still present a problem in the modern era with I.G. Jones and D. Cameron suggesting that 'Social Class [is] an embarrassment to epidemiology.'[71]

Additional challenges are also presented by gaps in our knowledge of the 'conduction' of specific infectious diseases in certain environments. This is best explained by considering the exact mode of operation of housing conditions in relation to tuberculosis. In the early part of the twentieth century the emphasis was on overcrowding and consequential insufficient air circulation.[72] This reflected the recognition of the airborne mode of infection of the bacillus, but it may be that it was not all that important in itself. Housing space standards, in terms of cubic capacity, were substantially reduced for new construction in the 1930s by a reduction in minimum ceiling heights, but this seems to have had no impact on the general decline in the incidence of mortality from TB.[73] This was probably because the new houses were better heated and less likely to facilitate general, debilitating respiratory infections.

This brings the discussion to the extension of Landers' concept of 'conduction'. It is argued that 'conduction' need not be one-dimensional. The threat to human physiology also requires investigation. It was noted in Chapter 1 that the majority of environmental problems in historic buildings are associated with water ingress, condensation and dampness in the building fabric and this can be an agent in the spread of disease. It will be shown that the thermal insulation of early modern buildings could have been severely compromised through dampness and another

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[70] Ibid.

[71] I.G. Jones and D. Cameron, 'Social Class: An Embarrassment to Epidemiology, Community Health Medicine' in *The Journal of Epidemiology and Community Health* (1984), pp. 44-50.

[72] One of the early reform leaders for better housing conditions as a preventative against tuberculosis was Mrs Albion Fellows Bacon, who identified in 1916 tuberculosis as a 'house disease.' Similar conclusions were reached by W.F. Walker in 1923 and S.J. Herman in 1929, quoted in Mood, 'Fundamentals for Healthful Housing' p.311.

[73] Byrne and Keithley, 'Housing and the Health of the Community' P.57

dimension of ‘conduction’ is revealed: increased heat-loss through the fabric of the structure, lowering temperatures and increasing condensation.

The building pathology analysis will examine contemporary reports on damp ingress into buildings, but rather than focusing purely on social groupings it considers the problem from the performance and function of building structures and materials common to all houses; a comparison is made in Chapter 5 between timber and brick structures. Chapter 7 will consider the possibility that any increase in building-related illnesses promoted by water ingress will have some relationship to economic and social factors.

The function, performance and use of a building relate to ‘retention’, the second proximate determinate identified by Landers as influencing mortality in the built environment. The relative capacities of buildings in the city centre, inner and outer suburbs to retain pathogens are compared whilst recognising that they shared the same building traditions and materials. What varied were the size and spatial disposition of properties, the quality of materials and workmanship in their construction, and the access to amenities and services provided.[74] Another variable is the standard and regularity of maintenance. Landlords in the wealthier city centre had an interest in maintaining the quality of their premises in order to uphold rents.[75] The maintenance of buildings is discussed in Chapter 5, and this directs this investigation towards the potential for structures to retain pathogens and also non-contagious diseases. The landlords in the inner suburbs appear to have to have considered their building as purely a commodity or economic unit.[76] Although the maintenance requirements for timber-framed buildings were high, the landlords would have been tempted to limit or postpone repairs if the costs exceeded their relatively low rental income from the ‘lesser sort’. Thus, social and financial considerations are a factor in the capacity of buildings to retain pathogens and non-contagious disease but so is the relative function and performance of the buildings. Building performance in terms of resisting damp, and measures to mitigate water penetration and condensation, are

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[74] Harding ‘Housing and Health’ p.35.

[75] Ibid.

[76] See expectations of buildings in David Watt, *Building Pathology*, pp. 22-25.

assessed across houses belonging to all social groups in Chapter 5. The method of maintenance to properties in early modern London needs to be considered.

Building pathology enables the application of indices of building material performances; these indicate the length of time necessary for building materials to deteriorate and reach the dilapidated stage specified in the contemporary reports of the Viewers and Surveyors. Specific examples are given in the building pathology analysis of the capacity for timber and brick to retain dampness. Building pathologists have also recognised the capacity of structures to retain dampness long after the source of ingress has been rectified.[77] There are inherent short-comings in structures and materials which influence the capacity of buildings to retain pathogens and a potential to pose threats to the physiology of the occupants, the most obvious examples being the internal privies without a water-seal trap and heat loss through the fabric.

The proximate determinants of 'conduction' and 'retention' will be considered in the context of social and economic conditions as well as the more obvious function and performance of building structure and materials; these are important variables in the assessment of London's mortality and morbidity profile. Landers argues that mortality levels reflect a balance between exposure and resistance to infection. His general analytical framework is based on a critique of the work of Thomas McKeown and suggests that the mortality level fully determined by social and economic conditions is expressed as:

M = f(Cn, Nu, Re), where Cn is conduction, Nu nutrition and Re Retention.[78]

McKeown argues that it was better nutrition that made the largest contribution to improved health. As noted in the opening Chapter to this thesis, McKeown's theory on the decline of infectious diseases still has currency, but his assertion about the role of nutrition has been challenged, not least in the early modern context. John Walter and Roger Schofield have observed that the connection between malnutrition, whether chronic or acute, and the ability to combat infection is far from clear-cut; they emphasise that malnutrition needs to be considered in a relative, rather than an

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[77] Hollis, *Surveying Buildings* and Watt and Swallow, *Surveying Historic Buildings.*

[78] Landers, *Death and the Metropolis*, p.13.

absolute sense.[79] What is at issue is not the volume of food that is eaten, or its nutritional composition, but whether it is adequate for the energy demands that the body has to meet. Apart from supplying the needs of basic metabolic functioning, sufficient energy needs to be available to counter the demands of parasites, and to resist infection. The balance that is struck between nutritional intake and energy output is known as 'nutritional status'. Thus individuals who eat very little may have high nutritional status, if they do not have to work and are not exposed to parasites or disease. Conversely, a person who has to live and possibly work in the cold, damp and disease-ridden environment of an early modern building may have a low nutritional status despite a large intake of food.

Thus, Walter and Schofield suggest that the situation is more complicated than the way in which historians have been accustomed to picture it. It is not just a matter of a simple causal step from insufficient food to a greater probability of dying from infectious disease. Since the incidence of disease is itself a factor in determining nutritional status, some scholars have argued that a mutually reinforcing interaction, or 'synergy', can occur, in which the presence or absence of disease affects the level of nutritional status, which in turn affects susceptibility to disease. Walter and Schofield conclude there are two variables in play which can disturb the normal balance of nutritional status in a population: fluctuations in the availability of food, and variations in energy demands, such as work, climate, or incidence of disease. As noted, Landers has expressed the above formula in the context of social and economic conditions and therefore takes into account the first variable put forward by Walter and Schofield.

Variations in energy demands may also be class-specific, but require further consideration. Much has been written about the poor housing conditions of the 'lesser sort' but Paul Seaver has assessed the mortality levels in the relatively wealthy parish of St Leonard in Eastcheap, where the artisan Nehemiah Wallington lived.[80] Seaver

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[79] For this and what follows on nutritional status, see Walter and Schofield (eds.), *Famine, disease and the social order in early modern society* (Cambridge, 1991), pp.17 -21.

[80] Relative wealth based on the mean dwelling size based on the number of hearths in London in the 1660s; see the map in Power 'The Social Topography of Restoration London' p.203. Craig Spence

noted of those whose age at death is known, 20 per cent died under the age of one, 42 per cent by age 10, and almost two-thirds (64 per cent) before reaching the age of 21. Only 8 per cent of those dying in the parish were aged over 50, and a mere 3 per cent were over 60.[81] In order to consider the social relationships between housing and health and the patterns of disease which result from those relationships, an investigation should include the health of all social groups.

A basic 'descriptive study'[82] places this investigation at risk of being undermined by social complexity and we must be wary of the observation made earlier by Jones and Cameron.[83] In their 'History of Mortality in London between 1550 and 1850,' Razzell and Spence have concluded that there appears to have been a minimal social class gradient in infant, child and adult mortality during this period. They state that 'This is an unexpected finding, raising fundamental questions about the role of poverty and social class in shaping mortality in this period.'[84] Razzell and Spence admit, however, that their research methods used in forming these conclusions are 'radical' and invite further investigation.[85] This is will be explored in the building pathology analysis on the premise that deaths by respiratory and enteric diseases were relatively high and constant, and consideration is given to the possibility that housing across all social groups was damp, cold and insanitary; the findings will be brought together in Chapter 7.

The formula produced by Landers evolves through his analysis of neo-classical theories on population history, such as the work of Wrigley and Schofield,[86]

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illustrates that East Cheap commanded high rental values for housing: see Craig Spence, *London in the 1690s:A Social Atlas* (London, 2000), p.71.

[81] Paul Seaver, *Wallington's World: A Puritan Artisan in Seventeenth-Century London* (Methuen and Co. Ltd, 1985), p.71.

[82] See section below on methods of housing-health research.

[83] Jones and Cameron, 'Social Class: An Embarrassment to Epidemiology' pp. 44-50.

[84]Razzell and Spence, 'History of Mortality in London' pp. 271-292.

[85] Ibid.

[86] E.A Wrigley and R.S. Schofield, *The Population History of England 1541-1871: A Reconstruction* (Cambridge University Press, 1989).

as well as other writers including W.H. McNeil, Kunitz [87] and Mary Dobson.[88] The analysis of these theories by Landers leads him to conclude that 'secular mortality levels reflect the balance between exposure and resistance to infection, each of which is determined by two further variables.'[89] The level of exposure depends on the number and character of the pathogens present in the environment (Landers calls this the 'pathogenic load'), and on the density of the matrix of pathways through which these can move between human hosts and non-human reservoirs present in the environment. Importantly, Landers notes that this matrix reflects the structure of the epidemiological regime itself, and its existence is dependent on the extent to which its pathways are exploited by the pathogens present in the environment at any given time. This is a crucial concept to grasp in analysing the 'waxing and waning' of diseases recognised by Graunt and a subject that is explored in Chapter 7, particularly with regard to enteric diseases.

The level of resistance to infection is affected by several variables, of which nutritional and immunological status is the most prominent. Thus, Landers expresses the determination of mortality at time *t*, in formal terms as:

> M = f (Cn, Pa, Nu, Im), where Pa is pathological load, Nu is nutritional status, and Im immunological status.[90]

As already noted, the proximate determinants of nutritional status are the quantity and quality of food intake - or diet - together with the capacity of the gut to absorb nutrients, and the energy demands made by the organism. The latter are themselves affected by morbidity, and although immunological status is chiefly a function of prior exposure, the response of the immune system can be impaired by inadequate nutrition.[91] Thus, the proximate determinants of nutritional and immunological status contribute to resistance. As the main question the thesis is seeking to determine is the influence of housing on health, the building pathology

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[87] Landers, *Death and the Metropolis,* p.12-33.

[88] Dobson, *Contours of Death.*

[89] Landers, *Death and the Metropolis,* p. 35.

[90] Ibid. pp.35-36.

[91] Ibid. p.36.

analysis will focus on the 'exposure potential' of occupants from all social groupings to building-related illnesses, and here Landers provides the formula:

> Ep = f (Cn, Re, Bo) where Ep refers to Exposure potential, Re to retention and Bo to bounding.[92]

Landers considers that the determinant 'bounding' should be considered alongside 'conduction' and 'retention'. His reasoning is that there is a potential for a collapse in what he terms the spatial bounding of local regimes, a collapse manifested in the phenomenon of stress-induced migration.[93]

Thus, the parameters for considering how housing can influence health in the early modern period have been identified through adapting the analytical model produced by Landers. Borrowing tools from *building pathology* has enabled an extension to this model. Having established the approach and parameters of this investigation, the final stage is to determine the nature of the investigation. The historical evidence referred to so far suggests that intervention in the environment improved the health of the urban populations from the late Victorian period onwards. *Building pathology* offers a method of studying intervention into the built environment.

2.3 The investigation method

The requirements of statutes and various sources of 'environmental law' under the main heading of 'building policies' are the focus of Chapter 4 and will consider intervention in early modern London's built environment. The 'intervention method' is one of five modern health studies used by building pathologists, and is easy to identify because such a study will analyse the results when attempts are made to change something; in this context, an analysis is made regarding a change in health in response to an alteration in the housing environment. A brief summary of the other methods used in modern *building pathology* studies would suggest that they are not mutually exclusive; this will be borne out by the building pathology analysis in Chapters 4-6. The other four methods are:

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[92] Ibid. p.38.

[93] Ibid. p.20.

- Descriptive*:* describes, and sometimes correlates, housing conditions and health at one point in time.
- Case-control: starts with ill people and compares their housing situation to that of healthy people.
- Longitudinal: follows people in different housing conditions over time.
- Extrapolative: measures directly a presumed health hazard but bases risk estimate on previous studies, often in a different setting.[94]

The consideration of deliberate attempts to manipulate the environment means that there will be some recourse to the 'Descriptive' method in charting the housing conditions of early modern London and attempts to relate this to the health of the occupants at a particular stage. 'Case control' studies are fraught with problems in the modern era[95] and the validity of this method in the early modern context is suspect, particularly in terms of 'under-matching' and 'over-matching.' In the case of the capital in the early modern period, John Graunt observed 'As for unhealthiness, it may well be supposed, that although seasoned Bodies may, and do live long in London, as elsewhere, yet new-comers and Children do not…'[96] Thus, the comparison of two apparently similar individuals of the same age, living in early modern London may be a case of 'over-matching' if the location of their birth is not considered. Razzell and Spence have sought to 'follow' cohorts in early modern London in a study in the 'longitudinal' tradition.[97] The findings of *People in Place* suggests that the 'longitudinal' study is unlikely to work as few Londoners lived for long in one place, and fewer still were born, married and died in the same parish.[98] John Kellett, a researcher into crowding and mortality in the modern era has observed that infectious diseases which ravaged Britain's urban concentrations in previous centuries are now under control, but evidence continues to emerge that crowding is a potent cause of disease. Through 'extrapolation', Kellet has observed that studies on

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[94] Mant, 'Understanding the problems', p.4.

[95] Ibid. pp. 8-9.

[96] Graunt, *Natural and Political Observations,* p.63.

[97] Razzell and Spence, 'History of Mortality', pp. 271-292.

[98] Harding *et al, People in Place*, pp.5-6.

animal population have demonstrated a wide range of physical and psychological effects from crowding.[99]

It is acknowledged that the above is a brief summary of the other four methods but there will inevitably be some further recourse to them in the Chapters that follow. Identifying the nature of this investigation largely as a 'intervention study' subjects it to detailed scrutiny by asking the following four key questions: has consideration been given to the selection of a 'control-group' in relation to the time changes? Is there selection bias? Has the problem of subjectivity been considered? Is the size of the 'trial' area an issue? [100]

With regards to time changes, Mant advises that the least satisfactory intervention research is the simple 'before-after' comparison. He considers this has little value because 'invariably it is impossible to dissociate benefit due to intervention from benefit due to the passage of time, however self-evident the benefit of intervention may seem.'[101] The 'control group' is the population living within and adjacent to the city walls, who were exposed to epidemics as well as being dislocated by the Great Fire of 1666. There has been recent debate about the number of fatalities caused by the Great Fire itself,[102] but the most significant factor was the impact it had in the temporary relocation of the population to the unburnt areas and the number who returned after the Fire. In terms of the building fabric, Thomas Reddaway noted that ten years after the Fire, the secular re-building was complete.[103]

People in Place make a 'before and after' comparison following the re-building of the city centre which highlighted a lack of benefits from a health perspective: worsening infant mortality rates were noted despite the renewal and

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[99] John M. Kellett, 'Crowding and Mortality in London Boroughs', in Burridge and Ormandy (eds.), *Unhealthy Housing*, p.209. At the time of publishing this work Kellett was a consultant psychiatrist and Senior Lecturer in Geriatric Medicine at St. George's Hospital Medical School, University of London.

[100] Mant, 'Understanding the problems ' p.12.

[101] Ibid.

[102] Gustav Milne, 'London's Burning Conference' Museum in Docklands, 6 October 2007.

[103] Reddaway, *The Rebuilding of London*, p.284.

improvement of the urban fabric and the decline in its population.[104] The time-lag problem identified by Mant may be a major obstacle in making a 'before and after' comparison of the early modern city centre but the views of some historians suggest that we should not be deterred from this line of inquiry. Despite Reddaway's conclusion that 'every effort had been made [in the Rebuilding Act] to reduce shortcomings and abolish evils',[105] George questions whether or not the houses were habitable from a sanitary perspective. In her view it was not within the scope of the Rebuilding Act to address sanitary issues and thus consideration needs to given to whether the intervention by the statutory authorities was 'conceived from the point of view of the street rather than the occupier.'[106] This is discussed in more detail in Chapter 4 but in terms of a conceptual model, however, this analysis is working to the proximate determinants in time and place as formulated by Landers.

The conceptual problem of time change pertaining to detecting illness was raised in Chapter 1, particularly regarding the issue of assuming that most individuals lived long enough in defective properties for the effect on their health to be significant.[107] A review of modern studies may address this issue. Susan Smith *et al* considers that stress and depressive illness are likely to be linked with current housing conditions, as are frequent episodes of acute respiratory illnesses. Long-term implications for health, however, may be experienced many years later, perhaps at a time when the current housing conditions are good or at least improved. For example, there is growing evidence of an association between frequent or severe bouts of respiratory illness in childhood and lung infection in later life.[108] There appears to have been very limited social mobility in the study period and this may be a key determinant in the early modern context,[109] with the transient population less likely to

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[104] *People in Place*, p.29.

[105] Ibid.

[106] George, *London Life*, p.86.

[107] Harding, 'Housing and Health', p.28.

[108] Byrne and Keithley, 'Housing and the Health of the Community', pp. 42-46.

[109] Ian W. Archer, *The Pursuit of Stability: Social relations in Elizabethan London* (Cambridge University Press, 2002), pp. 14-15; Guillery, *The Small House*, pp.10-17; L.D Schwarz, *London in the*

be moving to a healthier environment. An analysis of the function and performance of the houses in Chapters 5 and 6 may also assist in making comparisons between the internal environments of different forms of construction.

On the question of selection bias, Mant considers that even if people receive intervention in an unrandomised way, there is always a reason for their selection: 'they are always more deserving, more sick, more complaining etc.'[110] The Fire was not confined to one social area in the city. Harding's broad characterisation of housing maps the distribution of wealth within the city walls. The wealthier members of society were mainly located in the taller better-built houses which lined the most desirable street frontages of the city centre; in the side streets, however, artisans and craftsmen were housed in two or three storey dwellings. Along the waterfront warehousing, brewing and other commercial activities seem to have diminished the quality of the environment, so that the large old houses had been often divided into tenements or smaller dwelling units and rents were much lower. There was a broadly concentric distribution of housing quality, and therefore wealth, declining towards the city walls where houses were smaller and cheaper.[111] The extent of the Fire ensured that there is little selection bias in this investigation, destroying all these areas with the exception of the north-east section.

The problem of the subjectivity of the researcher arises from making the assumption that a group of people are suffering from building-related illness and looking for evidence to confirm this premise. The inadequacy of housing is invariably associated with other hardships,[112] but the model developed by Landers, expressing the proximate determinants of mortality, shows that nutritional and immunological status are a part of housing. Exposure to damp cold buildings will influence these determinants but should housing effects be isolated from those of other factors? In the modern context, for example, some have argued that once passive smoking and social class are controlled, the relationship between damp and mould and wheezing in

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age of industrialisation: entrepreneurs, labour force and living conditions, 1700-1850, pp.7-74 and pp.157-240.

[110] Mant, 'Understanding the problems 'p.12.

[111] Harding 'Housing and Health' pp. 35-6.

[112] Mant, 'Understanding the problems', p.3.

infancy practically disappears.[113] Thus, considering accounts of people coughing in early modern London, one also has to be aware that smoking was wide-spread. A native of Brandenburg noted in 1598 that 'the English are constantly smoking the Nicotan weed [Nicotiana] which in American is called Tobaca.'[114] Smoking was largely a male preserve, but smokers' wives must have noticed its negative effect on the breath: 'It makes your breath stink like the piss of a fox.'[115] A prescient clinical observation was made in 1599 by a Swiss medical student studying the smoking habits of Londoners, 'I am told that the inside of one man's [smoker's] veins after death was found to be covered in soot just like a chimney…'[116] Smoking probably increased significantly in seventeenth-century London as the price of tobacco fell and imports soared.[117] Byrne and Keithley consider, however, that if smoking and social class are seen as part of housing (or vice versa), then this becomes clearly a case of 'partialling out', a concept discussed in chapter 1.

On the matter of the size of the study area, Mant considers that most 'trials' are often too small and therefore do not have the 'power' to detect with statistical significance an important difference in outcome between the trial groups; important effects are often missed.[118] Cooper notes that the Fire statistics from 1666, though arguable, are stark. Less than twenty per cent of the area inside the walls (about 440 acres, or 180 hectares) remained untouched by the flames. About 13,000 houses were destroyed, making at least 65,000 people homeless, but the number might have been as high as 80,000.[119] The definition of what constitutes a house is just one argument

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[113] Byrne and Keithley make reference to this in 'Housing and the Health of the Community' p. 44.

[114] Hentzner inW.B Rye, *England as Seen by Foreigners,* (London, 1865), quoted in Liza Picard, *Elizabeth's London* (Phoenix , 2003), p.257.

[115] Dekker, *The Honest Whore,* Act II, scene I, (Dodo press, 2009).

[116] Platter in Razzell, quoted in Picard, *Elizabeth's London*, p.257.

[117] Jordon Goodman, *Tobacco in History: The Cultures of Dependence* (Routledge, 1993), p.63.

[118] Mant, 'Understanding the problems', p.12.

[119] Cooper, *Robert Hooke*, p.102. These figures would appear to include those areas outside the walls, and are also quoted by Stephen Porter, *Pepys's London: Everyday Life in London 1650-1703* (Amberley 2011), p.132.

that has developed in considering the statistics, but the main study area is considered large enough to address the problem of size in this method of research.

2.4 Conclusion

As anticipated in any 'critical appraisal', addressing the main question upon which the thesis is based raises further key questions. The question of how to approach the investigation has required an in-depth discussion on whether the state of health of early modern London should be viewed from the perspective of individual attributes or those of the community. This discussion in the early modern context has clear parallels with the conceptual and methodical challenges facing researchers in the modern era. The consideration of problems in research in the modern era alongside those of this historical study is vital for a twenty first-century analytical tool of *building pathology* is to be engaged in this thesis.

Criticism has been observed of those areas of research into building-related illnesses which seek to determine the health of the population at the level of the individual patient and at the expense of public health; here again, clear parallels with the approach of some eminent writers and clinicians in the early modern period have been discussed. Some historians have questioned the virtue of studying aggregate health and have sought to at least break their analysis down to the lowest common dominator through family reconstitution. Although historians using this technique have undertaken much research,[120] there are clear limitations in the context of a large early modern city. Consideration has been given to the possibility that the focus on the curative health care of the individual in both the early modern period and modern era has helped or hindered research.

Closer examination of the two approaches has revealed that some writers and clinicians in both the early modern and modern periods have looked upon epidemiology and clinical studies as complementing one another. Such an approach would be viable if there was more certainty over accurate diagnosis in the cause of illness in the individual patient. Doubt in the accuracy of diagnosis in the modern era has been noted, not least in the area of respiratory illnesses, which is a key area of

[120] See the work of Gill Newton 'Infant Mortality Variations, Feeding Practices and Social Status in London between 1550 and 1750' *Social History of Medicine*, 24:2, pp.244-259.

investigation in this study. Modern research has highlighted inherent problems with case-centred studies. On this basis, together with the passage of time, it would not be possible to rely upon the accuracy of diagnosis of early modern medical practitioners. This also brings into question the findings of clinicians to supplement the work of epidemiologists. It could be argued that not being able to assess health from the perspective of the individual completely undermines the validity of research into building-related illnesses in the early modern period.

It is the discourses in *building pathology* that have justified the approach of viewing the health of early modern London from the perspective of the community and vindicating the inductive reasoning in the work of John Graunt. It is stressed, however, that the selection of the aggregate technique has not been made through default, brought about by the short-comings in clinical studies. Rather the aggregate technique through the study of community health recognises the causal systems of diseases, comprising proximate determinants, which may vary in their influence in time and place, and produce fluctuations in the virulence of building-related illnesses.

The study of early modern London's population collectively based and spatially ordered, is the essence of 'social epidemiology', referring to the social relationships between housing and health and the patterns of disease which result from those relationships. The diseases that are the focus of this study are enteric and respiratory, considered by Graunt and building pathologists alike, to be key indicators in the healthfulness of a city. In view of the limitations recognised in the research into these diseases, however, a philosophical justification of our methods of understanding the phenomena we are investigating has been sought. This approach to 'social epidemiology' is informed through a 'realist' rather than a 'positivist' epistemology.

'Realism' deals precisely with the causal systems of enteric and respiratory diseases. An understanding of the realist position has been given through the example of the contraction of tuberculosis, but consideration should also be given to why the greatest contributions made by scientifically informed measures to public health were in fact informed by scientific error. The introduction of public health interventions was influenced by a miasmic theory of infectious disease. It was thought that eradicating the smells would remove the disease; and of course eradicating the source of smells resulted in an improvement. In reality, clean water,

decent scavenging and effective sewers eliminated noxious micro-organisms along with the harmless ones which caused the decay of organic matter. It was the 'urban ecology' that caused early nineteenth-century urban disease and public interventions transformed that ecology.[121] The Victorians changed the system; the building pathology analysis in this thesis considers the nascent intervention into early modern London's urban ecology.

[121] Byrne and Keithley, 'Housing and the Health of the Community', p.57

Chapter 3
Reconstructing the built Environment

The principles upon which *building pathology* is based rely on a detailed knowledge of how a building is designed, constructed, used and changed, and the various mechanisms by which its structural, material and environmental conditions can be affected.[1] In this study of London's housing from 1500-1720, with a particular focus on the city centre, it is apparent that the investigation is of a forensic nature. There are no pre-Fire houses remaining in the city centre and few post-Fire structures.[2] A historical reconstruction of the built environment is therefore required. Only by the reconstruction of London's buildings in this study period can we attempt to identify the defects that are associated with building-related illnesses.

As also noted in the opening Chapter, although physical evidence of buildings in early modern London is scarce, the city is rich in source material, not least panoramas and maps; pictorial and photographic evidence of buildings surviving into the nineteenth and twentieth centuries; the fragments of existing buildings; archaeological excavations; records of property holdings and management including repairing and rebuilding; and contemporary reports on buildings and their condition. Some specific examples of sources are given to illustrate particular points, but the in-depth analysis comes later in the thesis. The aim of this chapter is to consider whether the sources are useful in presenting the bigger picture with particular regard given to description and currency. In this context, 'description' means considering the extent to which the source explains, illustrates, chronicles or provides a narrative of the built environment; 'currency' relates to the degree to which a source can be relied upon, particularly in isolation.

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[1] Watt, *Building Pathology*, p.7.

[2] Schofield, *Medieval London Houses*, p.1.

3.1 Panoramas and maps

Despite the great wealth and political power of London built-up during many centuries, Hugh Clout suggests the first detailed depictions of the city did not appear until the 1550s[3] although Schofield is of the opinion that Wyngarde's panorama (figure 3.01) was produced circa 1540.[4] Panoramas along with three-dimensional 'map-views' and two-dimensional maps were the most common forms used in the depiction of London at the time.

Figure 3.01 London Bridge from Wyngaerde's panorama.

The Oxford English Dictionary defines a panorama as an 'unbroken view of a surrounding region' or 'a picture containing a wide view.' The convention and practice of the time was to produce the view from an elevated position. Intricate panoramic views of the city started to be produced in the mid-sixteenth century,

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[3] For this introduction to the mapping and depiction of the City, see *The Times History of London*, (Hugh Clout, Ed.), p.14.

[4] Schofield, *Medieval London Houses*, p.13.

almost a full century after the earliest European maps had been engraved in Italy.[5] The value of panoramas is that they show overviews of the city and also provide some details of house construction. Wyngaerde's panorama shows the shape and form of the buildings, with chimneys visible on the nearest structures. Features such as dormer and bay windows are also illustrated.

Wenceslaus Hollar (1607-77) also produced panoramas, including the Long View Bankside in 1647 and one showing the destruction of the city following the Great Fire. Derek Keene has observed that London's profile during this period had been generally portrayed from the ground or some elevated position on land,[6] but it is also likely that the vantage point in some cases was notional. In being aware of the conventions and practices involved in producing these depictions of London we will avoid the dangers of considering them as being truly authentic representations or 'photographic'. The panoramas do say something, however, about some of the issues that are the focus of this thesis such as the depiction of building form and density.

Peter Borsay refers to these early modern panoramas as 'prospects' and he considers that there was often little distinction between these and the early maps.[7] The first substantial collection of English town maps was published in Cologne as part of Braun and Hogenberg's multi-volumed *Civitates Orbis Terraraum* (1572-1618).[8] Ralph Hyde notes that such sixteenth- and seventeenth-century London maps were all in reality 'map-views', depicting each building in bird's-eye fashion whilst maintaining, as far as was practicable, a constant scale throughout.[9] On the other hand Borsay suggests that they were produced for a limited domestic market as objects of display and ornament and were inaccurate and therefore had little practical use.[10]

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[5] *The Times History of London*, p.14.

[6] Derek Keene 'Tall Buildings in the London Landscape' (*The London Journal,* Vol.33, No.3, November 2008), p.210.

[7] Peter Borsay, *The English Urban Renaissance: Culture and Society in the Provincial Town, 1660-1770* (Clarendon 1991) p.83.

[8] Ibid. p.81.

[9] London Topographical Society, *The A to Z of Restoration London: The City of London, 1676,* (London 1992, Publication No. 145), *pp. ix-xi.*

[10] Borsay, *The English Urban Renaissance*, p.81.

Map-views did have limitations in terms of their scale. Surveyors working in the modern era are aware that the standard and accuracy worked to is largely influenced by the scale of the survey drawings.[11] In the context of this thesis, however, consideration is given to possible sources of building-related illness being depicted in these map-views such as overcrowding and the lack of daylight into the narrow streets.

The 'Copperplate Map' was produced in circa 1633 and probably derives from the 'Copperplate' map of circa 1550 of which three sheets are extant.[12] Each section of the map is engraved in copperplate and it is thought that there would have originally been fifteen sections.[13] Although this map gives some critical information on the early topography of the city, Keene notes that the height of St. Paul's cathedral is probably exaggerated in relation to nearby houses, other churches, the city walls and gates and elite residences on the waterfront.[14] Other sixteenth-century surveyors such as John Norden (1547-1625) produced map-views of London in 1593[15] and this style of depiction continued into the seventeenth century not only in the capital but also in other towns.[16] In John Speed's *Theatre of the Empire of Great Britain* (1612) plans of seventy-three towns were inserted into the county maps.[17] The science of map making was new at this time and survey techniques were poorly understood.[18]

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[11] The thickness of a fine pencil line is in the order of 0.2mm and this sets an upper limit for the accuracy of any plot. If a building survey is to be plotted at a scale of 1:100, a dimension of 0.2mm on paper will represent 0.2 multiplied by 100 , equalling 20 mm on the building being measured; see Peter Swallow, David Watt and Robert Ashton, *Measurement and Recording of Historic Buildings* (Dorset, Donhead Publishing, 1993) p. 5.

[12] www.british-history.ac.uk/source.aspx?pubid=5, accessed 1 September 2013.

[13] http://www.museumoflondon.org.uk/archive/exhibits/lostmap/lostmap.htm.

[14] Derek Keene, 'Tall Buildings' p.205.

[15] Frank Kitchen, 'Norden, John (*c.*1547–1625)', *Oxford Dictionary of National Biography*, Oxford University Press, 2004; online edn, Jan 2008 [http://www.oxforddnb.com/view/article/20250, accessed 29 September 2013].

[16] For example, Gilmore's map of Bath in 1694, illustrated in Woodward, Christopher, *The Building of Bath,* (Barnes Printing, Bristol, 2008) p.3.

[17] Peter Borsay, *The English Urban Renaissance,* p.81.

[18] Ibid and also see, Peter Swallow, *et al Measurement and Recording of Historic Buildings*, pp.1-5.

Speed's atlas was an important landmark, but the following half-century witnessed little progress in the science of town mapping.[19]

Newcourt's map-view was drawn in 1658, and published in facsimile by Edward Stanford in 1863. There are only two copies of the original 1658 map known to exist. One is in the Bibliotheque Nationale in Paris, and the British Library has the other copy (which is minus its title). In an elegant flourish, Newcourt assures the purchaser that his map is drawn to scale. The extract shown in figure 3.02 is an engraving and consideration has to be given to the possibility of details being lost or changed when an engraving is made of the original drawing.

Figure 3.02 A section of Newcourt's map, showing Moorfields and east Cheapside.[20]

[19] Ibid.

This extract shows part of Cheapside and the area is filled with a conventional design of ziz-zag roofs meeting at shared valley gutters, representing possible sources of damp penetration to be considered in chapter 5. Newcourt also illustrates factors that may have had an effect on the performance of building materials, such as roof tiles. The west side of each roof is shown in sunlight and the east side in shade. The south and west elevations would have received the sunlight for the main part of the day and the driving rain from the southwest. Although these elevations would have received most of the weathering, the clay roof tiles on the cold shaded east elevation would have suffered from frost damage which would have eventually lead to damp penetration problems.[21] With regard to the whole of Newcourt's map, a few notable buildings are distinguished, some streets are named, and a number index gives 130 churches presumably to guide the eye to the eminent streets on which they stand. Major open spaces are shown, such as Moor Fields in the above extract, gardens and large houses giving some indication of natural daylight and ventilation around the buildings. The general effect, however, is of a uniform mass of tightly packed houses in the city centre, suggesting possible conditions conducive to the spread of pathogens. The theme of high building density and possibly overcrowding is highlighted but as is noted later from other sources, the uniform houses shown on Newcourt's map would have to be substituted for a mixture of large and small. Rich and poor housing were often in close proximity and there is no reference to industrial buildings.[22] The possibility that the tall buildings put the adjoining smaller buildings in near-permanent shade is considered in detail later in this thesis.

The depiction of chimneys together with the accounts given by Evelyn and Graunt suggests that thousands of smoking chimneys should be added to Newcourt's map. This would certainly provide a more realistic picture of the external

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[20]https://www.google.co.uk/search?q=british+museum&espv=210&es_sm=91&source=lnms&tbm=isch&sa=X&ei=WirJUrTOYSQhQfcnIHQDA&sqi=2&ved=0CAcQ_AUoAQ&biw=1280&bih=598#es_sm=91&espv=210&q=british+museum+Newcourt's, date accessed 6 January 2014.

[21] Watt, *Building Pathology*, and Hollis, *Surveying buildings.*

[22] For the location of commercial and industrial buildings at the end of the sixteenth century, see the map on page 60, in *The Times History of London*.

environment even though John Evelyn considered that the buildings would have been hidden beneath the smoke.[23] During a visit to Court in 1652 Dutchman Lodewijk Huygens cast his eye back to the capital and was surprised that St. Paul's Cathedral and the bell tower were 'too much obscured by smoke.'[24] Matters did not improve in the post-Fire period, where in 1676 Robert Hooke observed a cloud of smoke over London and estimated the mass to be half a mile high and over twenty miles long.[25] Clearly it was not the intention of the map-views to show the pollution of London's air and one could argue that as they were for public consumption, the aim was to create an impression and atmosphere. Keene suggests that one particular aim of the map-views was to convey a sense of London being 'composed of social and devotional groups each with its own local identity and under the tutelage of the mother church' by emphasising the height of St. Paul's and the towers, pinnacles and spires of the parish churches.[26]

Figure 3.03 shows the far more sophisticated map-view produced by Hollar (1607-1677) around the same period as Newcourt's version. Good quality three-dimensional map-views of this type allowed the mapmaker to exhibit a wealth of topographical detail that his successors producing two-dimensional maps were obliged to ignore. Hyde observes that the maker had to be an artist; the products of his labours were documents of considerable charm.[27] In Hyde's view this method also allowed the artist to disguise his ignorance of topographical detail as well as his knowledge of it.[28] As the seventeenth-century surveyor, John Holwell observed: 'Those that are minded to draw the map of any Town, City, or Corporation, only with the Uprights of the Houses, will have no need to measure either the House, Courts, or

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[23] J. Evelyn, *Fumifugium*.

[24] Quoted in Cockayne, *Hubbub*, pp. 208-209.

[25] Robert Hooke, *Diary*, Henry W. Robinson and Walter Adams (eds.), *The Diary of Robert Hooke* F.R.S., 1672-16809 (London, 1935), p.251.

[26] Keene, 'Tall Buildings', p.204.

[27] London Topographical Society, *The A to Z of Restoration London*, p. ix.

[28] Ibid.

Allies thereof.'[29] This would present problems in looking to map-views in measuring the amount of light entering windows in houses in these areas.

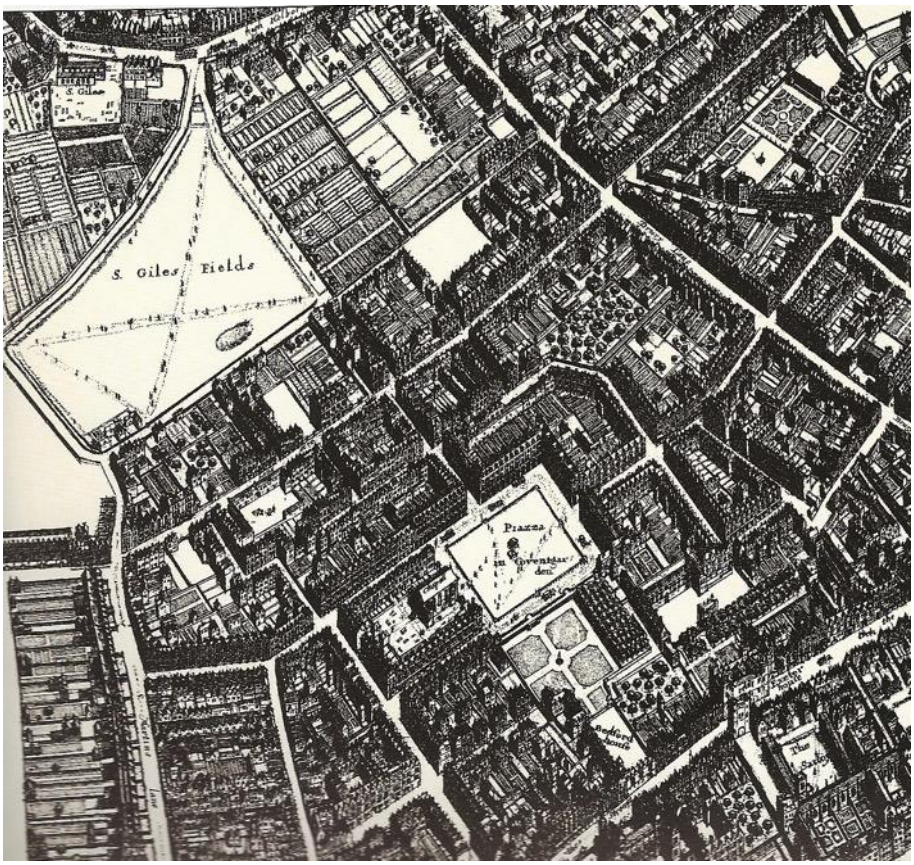

Figure 3.03 Hollar's 'map-view of west central London in the 1650s shows a bird's eye view of Covent Garden and many of the surrounding developments.

Recent research has considered the potential problems caused by the lack of daylight reaching the population of early modern London. Children of all classes suffered from rickets, through a deficiency of Vitamin D, essential for the absorption of calcium.There was little chance of Vitamin D being generated by the sun's rays in London's dark rooms due to the obstruction of windows caused by narrow streets and the polluted atmosphere.[30] If the maps are of an appropriate scale we can by using modern methods, measure the amount of light which would have penetrated the windows to buildings in a particular street, and this is considered in detail in chapter

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[29] John Holwell, *Sure Guide to the Practical Surveyor*, (London, 1678. EEBO Reel Position: Wing /1424:25).

[30] Maureen Waller, *1700*, p.100.

7. McKellar draws our attention to Hollar's two-dimensional depiction in his *London, Westminster and Southwark* map of 1664 (figure 3.04). As is noted below, Hollar also produced small detailed drawings of the elevations of buildings, demonstrating his wide technical skills but it is his venture into producing a two-dimensional map that recognises 'a fresh phase of growth and development' in town maps.[31]

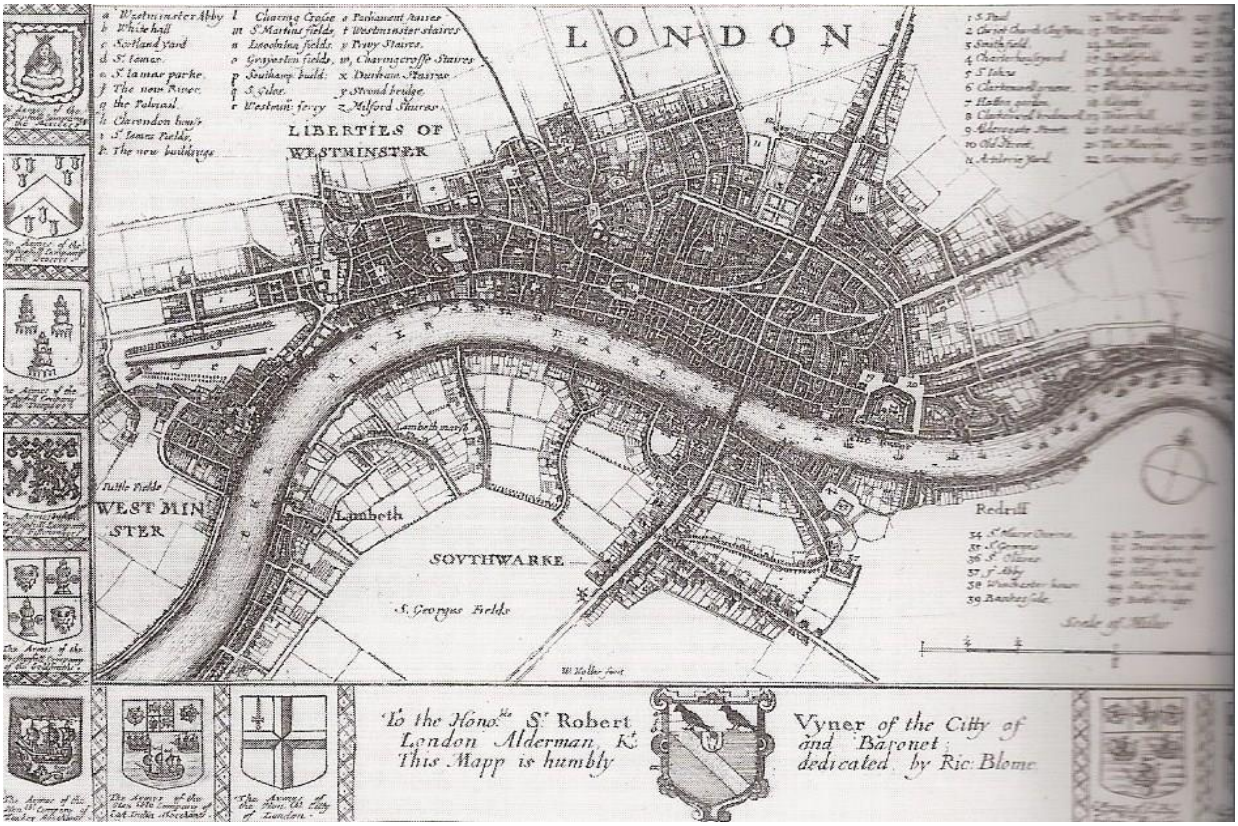

Figure 3.04 Wenceslaus Hollar's London, *Westminster and Southwark*, 1664.

According to Peter Borsay, it was from the 1660s in the case of London, and rather later in the provinces, that many urban centres acquired new two-dimensional surveys, which were regularly updated through the issue of later editions.[32] Underpinning the development of urban cartography in the years after the Restoration was a shift away from, what Borsay describes as 'the crude bird's-eye view', towards the more accurate two-dimensional survey.[33] Such maps were made possible due to the science and practice of surveying reaching a stage where all the basic items of

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[31] Borsay, *The English Urban Renaissance*, p.81.

[32] Ibid.

[33] Ibid. p.82.

optical equipment available to the modern surveyor were in use by the late sixteenth century.[34] As surveying theory developed into a practical occupation, treatises were produced, first for scientific explanation, and later as surveying manuals for the increasing numbers of apprentices in the seventeenth century.[35] William Leybourn (1626-1716) was one such example. He was the surveyor John Ogilby appointed to take charge of the post-Fire City of London map. Leybourn was a writer on mathematics and also wrote about the theory and practice of surveying.[36] His most successful book was *The Compleat Surveyor*.[37]

The Great Fire of London stimulated the production of the two-dimensional map. In 1666 Leybourn proved his practical capabilities when, with five other surveyors, he carried out the post-Fire survey of the city.[38] Damage to the city was so extensive that publishers were dissuaded from reprinting from out-dated copper plates.[39] The vast survey Leybourn carried out for John Ogilby was without doubt his greatest practical achievement, with the large map of 1676 measuring eight feet by four feet. Hyde observes it is inevitable that with Ogilby seeking advice from Robert Hooke and associating with Wren and Flamsteed on a regular basis, that he adopted the most mathematically precise and scientific surveying methods.[40] The map was actually completed by William Morgan, Leybourn's step-grandson, after the death of the latter in September 1676.

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[34] Swallow, Watt and Ashton, Measurement *and Recording*,p. 5.

[35] Ibid.

[36] His first book, a joint work with a fellow surveyor, Vincent Wing, was *UraniaPractica, or, Practical Astonomie*. His next work *Planometrica: or the Whole Art of Surveying Land*, was published in 1650.

[37] The first edition is accessed through Early *English Books on-line*.

[38] The City Corporation had commissioned a map almost immediately after the Great Fire in the form of a six-sheet manuscript 'skeleton survey' produced by William Leybourne, John Leake, John Jennings, William Marr, Thomas Streete and Richard Shortgrave.

[39] The prohibition was ignored: Map makers John Overton and Robert Pricke published Fire maps regardless. For more on this see *The A to Z of Restoration London, p.v.*

[40] William Leybourn's Fourth edition, of *The Compleat Surveyor* (1674) is quoted in *The A to Z of Restoration London* . The first edition is available through Early English Books on-line. No new principles were introduced into surveying or cartography during the seventeenth and eighteenth centuries, although plane-tables, theodolites and levels were increasingly refined.

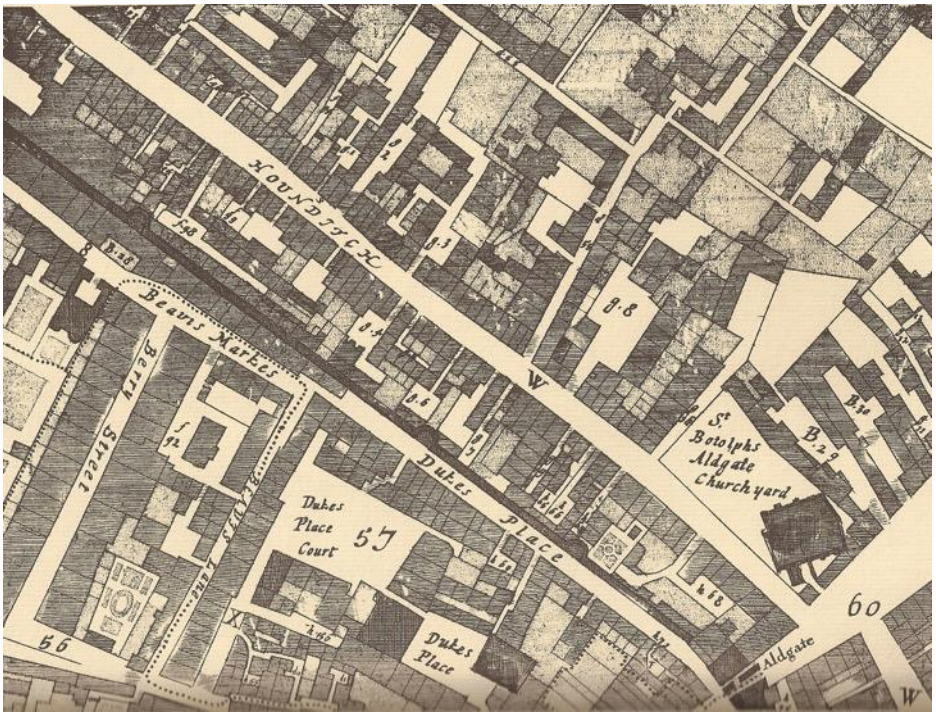

Figure 3.05 Ogilby and Morgan's City of London map. This extract shows the church and part of the parish of St. Botolph Aldgate and the redeveloped site of Holy Trinity Priory, named here as 'Dukes Place' and 'Dukes Place Court.'

Borsay is of the opinion that such maps would be recognised today as a 'true map.'[41]Although the Ogilby and Morgan map gave a reasonably accurate view of the city, Hyde highlighted its limitations. He observed that whereas the number of dwellings, together with their outline ground plans, shown in the main streets is likely to be correct the information supplied in the alleys and courts is less dependable; in some cases the representation in these locations is diagrammatic. This is likely to apply to the 'unburnt' area outside Aldgate, (fig. 3.05). *People in Place* have observed that backyards and open spaces in this area were built over with cheap, low-rise housing, forming a network of alleys and closes.[42] For the post-Fire period the Ogilby and Morgan map provides a reasonably accurate reconstruction; the widening and straightening of roads is clearly illustrated which would have improved natural lighting and ventilation. The opening up of the approach to London Bridge down Gracechurch Street and Fish Street to a width of thirty-five feet is also illustrated. The

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[41] Borsay, *The English Urban Renaissance,* p.82.

[42] Harding *et al*, *People in Place,* p. 27.

west entry through Ludgate from St. Bride's to St. Paul's was widened to forty feet. A minimum of fourteen feet was allotted to lanes and side streets; more open spaces were created. Knowing the type and approximate heights of buildings we can estimate the amount of daylight which would enter buildings in post-Fire London. Hyde advises us that the user of the London map must always bear in mind that it is not a large-scale Ordinance Survey plan, and it should never be used as if it were.[43]

Elevations of private houses and public buildings were frequently inserted into the two-dimensional maps of this period[44] but contours indicating the height of hills and declivities are generally absent. Schofield has included in his account of Medieval London houses a pre-Fire plan by David Bentley showing the contours of the city centre but does not indicate how this approximation of the ground surface was estimated.[45] As Bentley worked for the Museum of London, it is possible that the plotting was carried out for archaeological purposes. According to Reddaway the levels of streets were changed in some areas during the rebuilding of the city centre following the Great Fire to allow stagnant surface water to be drained away.[46] Knowledge of gradients is of value in assessing the following: the extent that low-lying properties were prone to rising damp; the risk of flooding; the requirement for high chimney stacks so that the latter functioned properly and avoided being a nuisance to neighbouring houses; surface water run-off in streets; effects on rubbish collection and street cleaning; and the stability of buildings on steep slopes down to the river.

3.2 Pictorial and photographic

For the purposes of this thesis, pictorial evidence and photography are considered along side each other for it will be shown that the similarities between antiquarian drawings and photographs are of great value in reconstructing the buildings. The pictorial evidence produced by the antiquaries, some of which were later engraved,

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[43] *The A to Z of Restoration London*, p.xi.

[44] Borsay, *The English Urban Renaissance*, p.83.

[45] Schofield, *Medieval London Houses*, p.7.

[46] Reddaway, *The Rebuilding of London*, p.296.

was drawn on the spot and some of the photographs taken of buildings from the mid-nineteenth century offer some potential to consider the accuracy of the drawings.

The earliest original drawings used by Schofield in his study of pre-Fire buildings are those produced by Wenceslaus Hollar, John Carter (1748-1817) and Jacob Schnebbelie (1760-1792). The pictorial evidence was remarkable for its own day and incidental to other subjects as it depicted, for example, the backgrounds of Hollar's drawings. In his 1646 drawing of Arundel House, in Fleet Street, Hollar provides intricate detail of the following: the irregularity of the buildings, with numerous pitched and flat roof dormers projecting from the main roofs; buildings of different heights and types are connected to one-another, without any obvious means of providing weather-tight joints; a timber-framed building, built-off a brick plinth; a flimsy external staircase. Hollar had a wide range of technical skills, not only as an artist but also as an architectural draughtsman. It would not appear that he received formal architectural training but his depiction of buildings is of a high quality.[47]

If we consider Carter's training and career there is much to justify his status as a reliable source in depicting the buildings of early modern London. He was a draughtsman and antiquary. He initially trained as a sculptor making drawings for the workmen. He established himself as a draughtsman and writer in the *Builder's Magazine* between 1774 and 1778 but it was as one of the draughtsmen for the Society of Antiquaries' series *Vetusta monumenta* that Carter first emerged as a notable figure and later established himself as England's first architectural journalist.[48] Schofield draws our attention to Carter's *Views of Ancient Buildings* of 1786-93.[49] His drawings of Ely Place in Holborn and Crosby Place, Bishopsgate exhibit the work of an architectural technician more than an artist. The details of the

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[47] Robert J. D. Harding, 'Hollar, Wenceslaus (1607–1677)', *Oxford Dictionary of National Biography*, Oxford University Press, 2004 [http://www.oxforddnb.com/view/article/13549, accessed 29 Sept 2013].

[48] J. Mordaunt Crook, 'Carter, John (1748–1817)', *Oxford Dictionary of National Biography*, Oxford University Press, 2004; online edn, Jan 2008 [http://www.oxforddnb.com/view/article/4791, accessed 28 Sept 2013].

[49] Schofield, *Medieval London Houses*, p.5.

roof construction, recessed brick arches in walls, and windows take priority over any artistic impression.

The credentials of Jacob Schnebbelie (1760–1792) as a topographical draughtsman were equally impressive. In his early career he became a drawing-master at Westminster and other schools. [50] Through the influence of Lord Leicester, the president of the Society of Antiquaries, Schnebbelie was appointed draughtsman to the society. In 1791 Schnebbelie commenced the publication of the *Antiquaries' Museum*, illustrating the ancient architecture, painting, and sculpture of Britain.[51] This work included interiors as well as elevations and in this regard he also produced drawings of Crosby Place, showing the inside of the great parlour and chamber above, with the first floor structure having been removed.

The buildings that were drawn by eighteenth- and nineteenth-century antiquaries were of the more remarkable or durable structures. Peter Guillery has drawn our attention to the work of Thomas Hosmer Shepherd (1793-1864) who was employed by Frederick Crace (1799-1859) to paint old London buildings prior to their demolition; some of these buildings were of a more humble nature and not necessarily of a high standard.[52] Much of Shepherd's work survives in the Crace collection at the British Museum and the London Metropolitan Archives. Shepherd was a watercolour artist well known for his architectural drawings. He was the son of an architectural draughtsman and was employed to illustrate architecture in London, and later in Edinburgh, Bath and Bristol. Shepherd's work, mostly topographical, is characterised by attention to detail, along with life-like scenes that contained people, carriages and horses. This obviously makes him a relatively reliable and important source in terms of the interaction of people with buildings of the study period.[53]

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[50] F. M. O'Donoghue, 'Schnebbelie, Jacob (1760–1792)', rev. Rosie Dias, *ODNB,*2004; online edn, Jan 2008 [http://www.oxforddnb.com/view/article/24811, accessed 28 Sept 2013].

[51] Ibid.

[52] A brief account of Shepherd's life is given by Lucy Peltz, 'Shepherd, George Sidney (1784–1862)',*ODNB,* 2004 [http://www.oxforddnb.com/view/article/25331, accessed 28 September 2013].

[53] Shepherd and Elmes, *Metropolitan Improvements or London in the Nineteenth Century,* (London , 1827).

Shepherd provides a wide range of evidence and this is possibly why he is one of Guillery's main sources in his work on small eighteenth-century London houses.

Another source of information about more humble housing is J.T. Smith (1766-1833). His published work focuses almost entirely on London and its environs, and he was unusual for his time in that he recorded all strata of society.[54] For example, figure 3.06 shows his drawing of a dwelling shed.

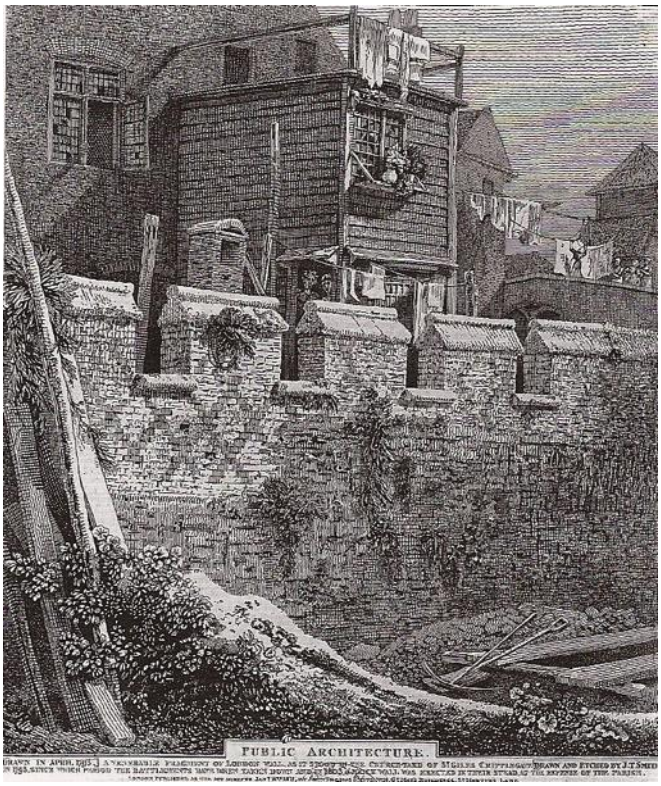

Figure 3.06. A 'dwelling Shed' located on the north side of the City wall in the churchyard of St Giles, Cripplegate, by J.T. Smith (1793).

As will be seen later in this thesis, the dwelling shed is frequently referred to in contemporary reports and categorised by William Baer as being at the bottom of the housing hierarchy.[55] The limitation of Smith's depiction of the shed, however, is

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[54] Lucy Peltz, 'Smith, John Thomas (1766–1833)', *ODNB*, 2004; online edn, Jan 2007 [http://www.oxforddnb.com/view/article/25867, accessed28 Sept 2013]. J.T Smith is also a source for some of the more durable buildings referred to by Schofield. His first acclaim, however, covered a latter period with *Metropolitan Improvements*, a publication of nineteenth-century London architecture commissioned by Jones and Company.

[55] William Baer, 'Housing for the Lesser Sort in Stuart London', *London Journal*, (Volume 33, Number 1, March 2008), p.68.

estimating the age of the structure. A basic building of this type would not have survived from the sixteenth or seventeenth century through to the period when Smith drew it. Smith is nevertheless considered a reliable source. He began his career as a pupil of the Royal Academician Joseph Nollekens and the mezzotint engraver John Keyse Sherwin. In 1816, Smith became the keeper of prints and drawings at the British Museum, a position he held for the duration of his life. He completed *The Ancient Topography of London* in 1815 and continued to publish various literary and illustrated works throughout his life.[56]

Another of Smith's commissions provides a particularly interesting insight into how the same building can be portrayed differently by two separate artists; this also illustrates the pit-falls in looking at pictorial evidence in isolation. Smith shows a typical view of a distorted timber framed building, while the other artist C.J. Richardson (1806-1871) shows the same building, standing upright and true. Richardson was a pupil of Sir John Soane from 1824 to 1830. Richardson is chiefly remembered as a pioneer of the Victorian appreciation of Tudor and Elizabethan architecture and as an architectural draughtsman and collector of architectural drawings. In a revealing account of Richardson's character it would appear that he possessed a romantic view[57] and this casts some doubt on whether he is a reliable source for the reconstruction of early modern houses.

In the eighteenth century antiquaries were depicting buildings still in use but were perhaps more picturesque than reality. Nineteenth-century artist were depicting that which might be lost and this work was replicated to some degree by photography. As with the drawn pictorial evidence, consideration must be given to the intention of the photographer. For example, the 'Society for the Photographing of Relics of Old London' set about using photography as a means of documenting buildings that represented 'old' London threatened with destruction. On their Web site the Society state that they were formed by a few friends who wanted to record the Oxford Arms Inn which was under threat to be demolished to allow the expansion of nearby

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[56] Peltz, 'Smith, John Thomas', *ODNB.*

[57] Campbell Dodgson, 'Richardson, Charles James (1806–1871)', rev. Robert Thorne, *ODNB*, 2004 [http://www.oxforddnb.com/view/article/23547, accessed28 Sept 2013]

Old Bailey. The availability of the 'photographic views' was publicised through a letter to The Times newspaper and as the project was well received, it was found practical to continue the series. In all, twelve issues were produced over twelve years from 1875, comprising a total of 120 photographs.[58]

Figure 3.07 is a photograph taken in 1927 and is from the records of English Heritage. It suggests that the photographer is attempting to record his interpretation of 'old London.' This photograph of a row of timber-framed buildings in Colombo Street, Southwark date from around 1700 and seems to portray a quaint but contrived domestic scene.

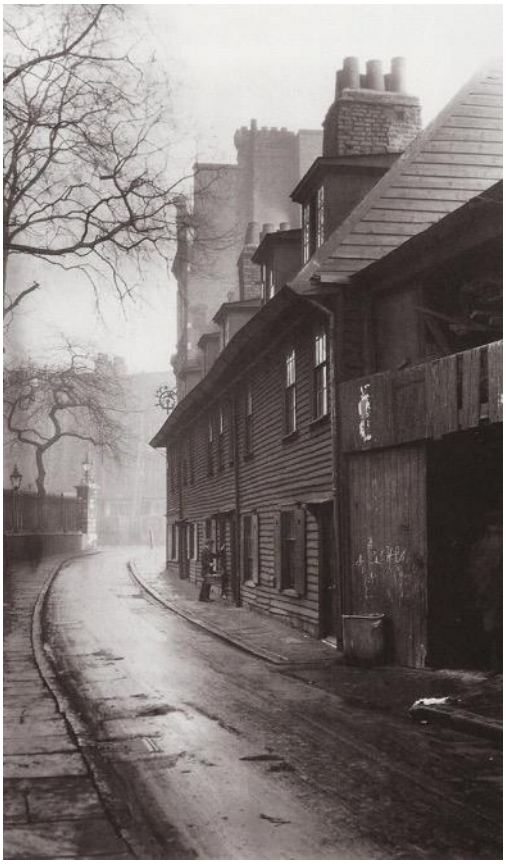

Figure 3.07 Seventeenth-century timber houses in Southwark.

This example shows, however, the value of such photographs in providing a means to confirm the accuracy of drawn pictorial evidence in nearby Ewer Street. Figure 3.08 by Thomas Hosmer Shepherd shows timber-framed buildings of a similar

[58] http://www.racollection.org.uk.

construction, with horizontal timber boards to the elevations and dormer windows projecting from the roof and centrally placed chimney stacks behind the apex of the roof. Casement windows are shown in the Ewer Street drawing, whereas double hung sashes are installed in the houses in Colombo Street; it is possible that the latter are original.[59]

Figure 3.08. Timber frame houses of c.1690 on Ewer Street Southwark.

The following example of a post-Fire house in Bedford Row illustrates the importance of understanding buildings at different levels in order to build up an accurate picture. Number 36 Bedford Row was built circa 1693 and re-fronted in the early to mid eighteenth century. The clue is the windows being set-back to comply with the later regulations, rather than being flush with the brickwork as would have been the case immediately after the Great Fire. This is a particularly interesting example as it is remarkably close to Summerson's elevation shown earlier in figure1.02 in Chapter 1. McKellar considers that this house may have served as the model, with the exception of the change in the windows from casements to sashes and the replacement of the original wooden dentil cornice.[60] Photographs are also

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[59] Sash windows were imported from Holland into England in the late seventeenth century, Pevsner *et al*, *The Penguin Dictionary of Architecture*, (Penguin Books, 1999), p.506.

[60] McKellar, *The Birth of Modern London*, p.168. A dentil is a small square block and a cornice the projecting section along the top of the building.

particularly useful in recording excavations and remaining evidence of foundations, walls and drainage systems.

Figure. 3.09. No. 36 Bedford Row, WC1.

3.3 Remaining buildings

There are only seventeen surviving fragments of secular pre-Fire buildings in the city centre. These are almost all fragments of well-built, prestigious buildings, and though a small number of London undercrofts date from the thirteenth century (most notably, the west undercroft of Guildhall), the majority of the standing remains date from the fifteenth or sixteenth century.[61] The study of the small number of remaining medieval undercrofts is useful as they provide clues as to the type of structures utilised in the early modern period in the city centre; these subterranean structures often formed the foundations and basement to sixteenth- and seventeenth-century timber-framed buildings. As will be seen later, it is also useful to compare these undercrofts of remaining buildings with those revealed through excavations.

It was noted earlier that historians as well as building pathologists have used a form of forensic investigation into early modern housing. Schofield offers another contribution to the forensic method, where he suggests that in the absence of timber framed buildings in the capital, we can look to those surviving in York and Kings

[61] Schofield, *Medieval London Houses*, p.2.

Lynn as 'models for the reconstruction of their long destroyed London counterparts.'[62] He considers that to walk around York today is to see in timber, and also brick and stone, the kind of buildings we are seeking to recreate on paper through a desktop study.

Figure 3.10 The timber-framed buildings of The Shambles in York

Part of my research has therefore involved a field study around York. I have photographed and recorded the type of materials and construction techniques as well as noting how these buildings have been repaired and maintained; this provides valuable information on the nature of the defects. In 1993 The York Archaeological Trust restored Barley Hall (figure 3.11), a fourteenth-century house and the study of this building provides evidence of the construction techniques and 'living with defects' such as dampness.[63] To walk around Barley Hall also provides physical evidence of how the buildings were used and altered. The restoration is obviously temporal and although the building dates from 1360, when clergy used it, the structure has been restored to the size and shape when a merchant's family occupied it in the late 1500s. Schofield is also confident that by studying the documentation of a particular building, we may discover what the buildings meant to the owners and occupiers.

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[62] Schofield, *The Building of London*, p. 178.

[63] Barley Hall, 2 Coffee Yard, Off Stonegate, York, Y01 8AR; www.barleyhall.org.uk.

Figure 3.11 Barley Hall, York

Peter Guillery has attempted to make similar comparisons with remaining buildings in what would have been early modern London's outlying districts. He has cross-referenced plans of housing in the city centre, which have long-since disappeared, with remaining structures to 'draw out threads of change and continuity over time' aiming to introduce themes that run through his case studies.[64] One such study has been a large-scale speculative development built in the years 1598 to 1616 on the fairground at St. Bartholomew, Smithfield. Such buildings were occupied by artisans and shopkeepers from the outset and were of timber, and comprised jettied and gabled frontages in keeping with traditional building practice.

One of the surviving buildings still has a jettied timber front, similar to those recorded in the pre-Fire city centre. The buildings had one room on each of the three floors. Shops were located on the ground floor, above a cellar, again following a layout that was typical of many pre-Fire city centre buildings.[65] From around 1610 brick was used at Bartholomew Fair, featuring flat frontages. Guillery considers this must have been a novel departure, possibly reflecting two new building proclamations

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[64] Guillery, *The Small House*, pp.40-4.

[65] Schofield has categorized this is a 'type 1' house is his broad categorisation of four house types in the pre- Fire city centre, in *The London surveys of Ralph Treswell*, pp.11-17.

of 1611, which prohibited timber building and jetties. Guillery also suggests, however, that this change in construction technique and style was also symptomatic of concern for amenity and urban improvement.[66] This is relevant to this thesis in terms of assessing the quality of natural ventilation and daylight around buildings; a detailed study is made in chapter 7.

Guillery has cautioned that care must be taken in studying remaining buildings, as inevitably there will have been extensive alteration.[67] Many such buildings would now be 'listed' under Section 54 of The Town and Country Planning Act 1971[68] as they are of special architectural or historic interest but alterations undertaken before this date would also be 'protected'. To some degree this may be a reflection of the Society for the Protection of Ancient Buildings (SPAB) manifesto written by William Morris and other founder members and issued in 1877. Although produced in response to the conservation problems of the nineteenth century, the manifesto extends protection to "all times and styles" and remains to this day the philosophical basis for the Society's work.[69] Thus, for the purposes of this thesis, a forensic investigation of a different nature is required with remaining buildings, in order to establish what is original. The study of documentation alongside the remaining buildings becomes even more essential.

The Wren Society and the archives of St. Paul's Cathedral provide a rare opportunity to trace a more detailed history of post-Fire dwellings in the city centre. The three residences in Amen Court (originally known as Amen Corner) were designed by an Edward Woodroofe and built between 1671-3 at a cost of £3,038-19s-1d. [70]

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[66] Guillery, *The Small House*, p. 41.

[67] Ibid.

[68] http://www.legislation.gov.uk/ukpga/1971/78/section/54/enacted.

[69] http://www.spab.org.uk/what-is-spab-/the-manifesto/, accessed 6 October 2013.

[70] Wren Society, Vol.13, Designs and drawings by Sir Christopher Wren for St. Paul's Cathedral, the residentiaries' houses, and the Deanery: original drawings from the All Souls collection (Oxford University Press for the Wren Society 1936), pp. 55-6.

Figure 3.12 Three Residences in Amen Court, the City of London, EC4.

Descriptions are given in the Cathedral's accounts of the excavations for the foundations and basement, and the construction of brick walls, along with carpentry, plumbing and paving work.[71] The earliest surviving drawings, however, date from circa 1857 (Figure 3.13).[72] There are no apparent records of major structural alterations since construction and the plans give no indication of substantial extensions being enclosed onto the original external walls. Figure 3.14 is taken from the 1958 survey by Lord Mottistone, F.S.A., FRIBA, who was the Surveyor to the Fabric and the floor plans do not reveal any major structural alterations and extensions. Although the building was constructed without a damp-proof course to the base of the walls, there is no visible evidence of past repairs to address rising damp. In his survey of 3 Amen Court, Mottistone, stated 'the basement appears to be free from damp.'[73]

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[71] Ibid.

[72] I am grateful to Catherine Angerson archivist for the Cathedral for searching the archives for the drawings on the 9 September 2008.

[73] The Survey of Cathedral Properties, St. Paul's Cathedral archives. This document merely has a title and no reference number.

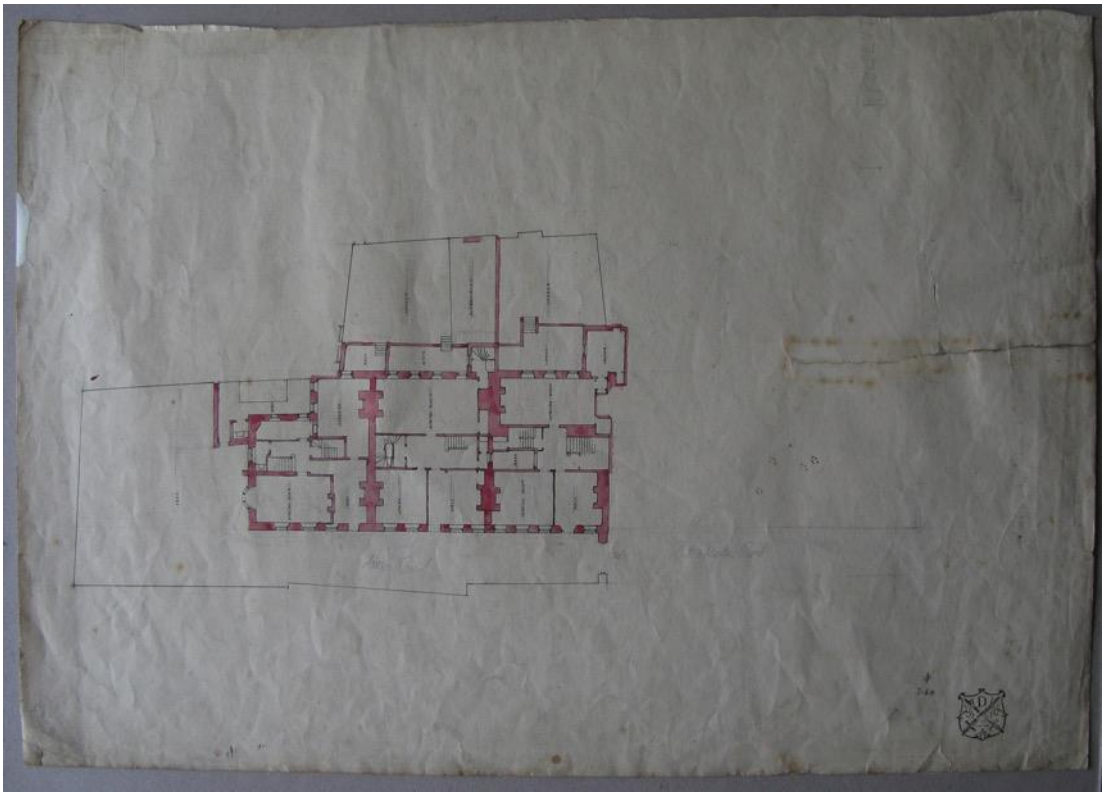

Figure 3.13 Record drawing of 1-3 Amen Court, circa 1857, St. Paul's Cathedral archives.

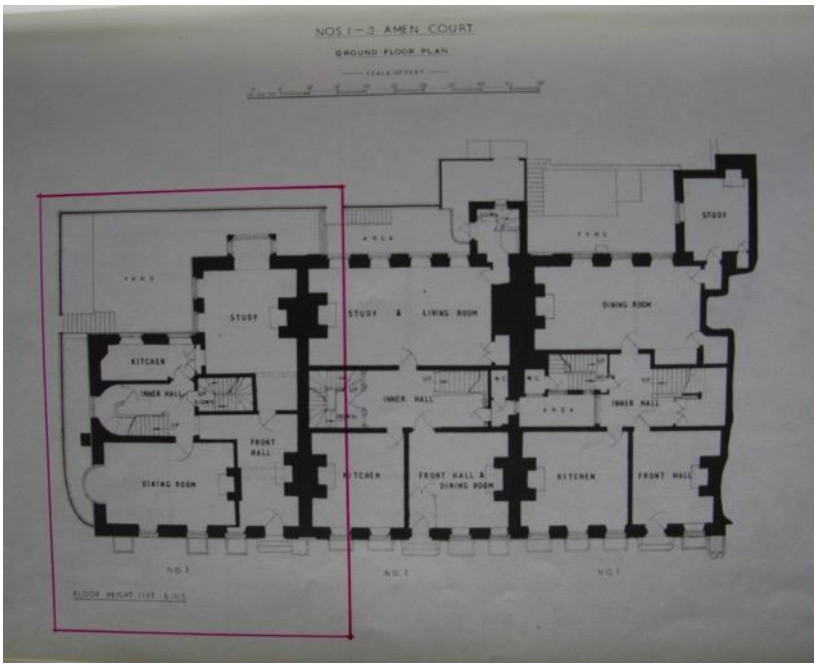

Figure 3.14 Nos. 1-3 Amen Court, from the 1958 survey by Lord Mottistone, St. Paul's Cathedral archives.

In the case of any remaining buildings of this era, however, repairs are inevitable which may in themselves bring about changes in the original building. My survey of 3 Amen Court has revealed that the original hand-sawn roof timbers have been replaced with standardised factory-sawn rafters; roofing felt has been placed beneath the roof tiles to provide additional weather-protection; parapets have been rebuilt incorporating damp proof courses; in some areas of the main walls a cement mortar has been used to the brick joints, which is more resistant to damp than the original lime-based mortar; sash windows have been substituted for the original casements and set back from the frontage.[74] The importance of identifying modern repairs to early modern buildings is to avoid errors in assessing the original performance of these historic structures. In fact, locating the areas of the building that have been repaired and 'improved' may provide clues as to past failures in the structure.

3.4 Archaeological excavations

With only a few early modern buildings remaining on the surface, the next source to consider is the archaeological reports. Martin Biddle expressed concern in the 1970s that this was a source under great threat. He observed that despite the efforts of 'a band of devoted antiquaries' over a century and a half, 'our knowledge of the archaeology of London is unsatisfactory in almost every respect.' [75] Biddle considered that 'There has been neither the finance, nor the administration, neither the staff nor indeed always the will, to ensure that the remains of the past threatened by the needs of the present were investigated, recorded, and published for scholars and the general interest alike.'[76] Up until the 1970s the emphasis of archaeological work in the city centre had been heavily concentrated on the Roman period.[77] It was

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[74] I am grateful to Cannon Martin Warner, Treasurer, St. Paul's Cathedral, who provided me with access to 3 Amen Court, 8 September 2008.

[75] Martin Biddle and Daphne Hudson with Carolyn Heighway, *The Future of London's past: a survey of the archaeological implications of planning and development in the nation's capital* (Rescue, Worcester, 1973), p.51.

[76] Ibid.

[77] Ibid.

argued by Biddle that the major problems facing archaeologists and historians could, however, probably be resolved by setting up an organisation specifically charged to investigate and record the remaining archaeological evidence before its destruction by future development: 'A City of London archaeological unit would, amongst many other tasks, conduct excavations, the observations of building site, the study and publication of its results.'[78]

In 1973, such an organisation was established. Now known as MOLA[79] (Museum of London Archaeology), it is an independent charitable company employing more than 200 professional archaeologists, consultants and specialists. MOLA work 'in partnership' with developers, planners and property managers. Information on the MOLA website is regularly updated, for example, regarding discoveries made by their archaeologists working on 'Crossrail' sites.[80] A significant site in the vicinity of Liverpool Street station is the Bedlam burial ground. It is hoped that the large-scale excavations in 2014 will involve the removal of 3,000 skeletons from the seventeenth century.[81]

The reports in the archives of the Museum of London show that pre-Fire and post-Fire domestic buildings have been excavated on a number of sites in the city centre. It is worth considering the format of the archaeological reports in terms of providing an initial overview of what they can offer to this investigation. The excavation reports are given a 'sitecode' typically with the pre-fix comprising the initials of the site or building, followed by two digits, indicating the year of excavation. In the opening chapter it was noted that the building density of the city centre was increasing through the extension, adaptation and subdivision of existing

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[78] Ibid.

[79] Formerly known as MoLAS.

[80] Crossrail is a railway construction project under way mainly in central London. Its aim is to provide a high-frequency commuter/suburban passenger service, also to be branded Crossrail, that will, from 2018, link parts of Berkshire and Buckinghamshire, via central London, to Essex and South East London.

[81] http://www.museumoflondonarchaeology.org.uk/NewsProjects/Current-News/ Accessed August 2013.

buildings.[82] The reports provide some clues to alterations and changes over time by following a consistent format of 'stratigraphy'. An analysis of the order and position of layers of the archaeological remains is given, indicating how materials were re-used from previous centuries, and the medieval foundations and cellars were used to support early modern buildings.

Biddle's concerns expressed in the 1970s appear to have been borne out by many reports making reference to the shallow remains inland having been destroyed by later buildings, particularly following the construction of cellars during the nineteenth century and a building phase in the 1950s.[83] Fragments of more ordinary domestic buildings are commonly found on sites throughout the city centre, but on inland sites, apart from fortuitous survivals such as the undercroft supporting a post-Fire house building at 7-8 Philpot Lane,[84] the remains which survive to be recorded are only the deeper foundations, cesspits and wells.[85] The recent 'New Change Excavation' at Cheapside, however, appears to offer some optimism regarding the quality of evidence on inland locations and this is discussed in more detail below.[86] Away from the inland locations the general situation improves on the waterfront

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[82] Schofield, *Medieval London Houses*, pp.59-60.

[83] MoL BDE00 Bow Bells House, Bread Street EC4; FHC00 56-59 Fenchurch Street, 18 London Street & 76 Mark Lane EC3; LOD00 10-15 Lombard Street EC3; MTN00 Middle Temple Hall kitchens, Middle Temple Lane EC4; TGT00 2-2a Throgmorton Avenue EC2.

[84] MoL, sitecode HIL84.

[85] For example, for cellars see: GHT00 Blossom's Inn, 20 - 30 Gresham Street, 20 – 23 Lawrence Lane, 3 – 6 Trump Street, 1- 10 Milk Street & Mumford Court EC1; POY00 Mercers Hall, Ironmonger Lane EC2. For cesspits see: BII005 Billiter Street EC3;EC4 NGT00 Paternoster Square, Area 4 and Paternoster Row; QVR00Walker House, 87 – 95 Queen Victoria Street EC4. For examples of wells see FHC00 56-59 Fenchurch Street, 18 London Street & 76 Mark Lane EC3.

[86] I am grateful for the information provided during a personal meeting with David Saxby, Project Officer for the most recent excavations in the *New Change* dig in Cheapside, Museum of London Archaeology, Mortimer Wheeler House, 46 Eagle Wharf Road, London, N1 7ED, (23 October 2009). At the time of writing this chapter, the archaeological report was in the process of being drafted by Saxby *et al.*

where the remains are generally better preserved. This is because the deposits are exceptionally deep due to the frequent raising of the ground against the Thames. [87]

The analysis of the reports across the city centre provides some information about building materials, floor plans, and the construction of foundations, cellars, walls, privies and wells. The building materials, along with the destruction debris, include fragments of tile floors, door and window mouldings, timbers and roof tiles. With regard to plans, excavations on the known sites of three great residences have produced partial plans: Neville's Inn, Warwick Inn and the Inn of the Bishop of Bath in the Strand.[88] More complete floor plans were revealed in the 'New Change Excavation' where the average plot size to individual buildings was 5 metres wide by 10 metres deep. This is of use to the analysis in chapter 4 when considering the size of dwellings relative to population density or crowding. The reports on the excavations of foundations are of value in assessing the performance of the structures in chapter 5 in terms of their ability to support the buildings, particularly when additional storeys were constructed.

It was noted earlier that medieval foundations and cellars were used to support early modern buildings. This may have been due to cost but it is also likely that the medieval foundations and cellars were utilised as they had remained structurally stable over many years. In the 'New Change Excavation' Saxby has observed some significant techniques in the construction of foundations in this part of Cheapside. There is information on new footings to the early modern buildings, as well as the adaption and repairs of Roman and medieval foundations used to support sixteenth- and seventeenth-century structures. The 'New Change Excavation' also provides an opportunity to compare the quality of medieval and early modern brick walls.

It is not realistic to expect the archaeological reports to be set out in a format that provides ready answers to the building pathology analysis, but the benefit of the meeting with David Saxby was to raise questions relating specifically to building defects. Information was provided on the following: quality of the construction of cellars and their damp-proofing performance; evidence of decayed floor timbers; the

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[87] MoL SUN86 Sunlight Wharf, Upper Thames Street; Tl74 Trig Lane, Upper Thames Street, EC4 and VHY89 Vintners' Place, Upper Thames Street, EC4.

[88] Schofield, *Medieval London Houses*, p.2.

position, construction and depth of cesspits and wells. This information is considered in detail in the building pathology analysis in Chapters 4-6. The findings of the 'New Change Excavation' are obviously confined to one area of the city centre but there are similarities with the information contained in the archaeological reports produced across the city. It is apparent, however, that the reconstruction of early modern London cannot be achieved by archaeological reports in isolation. This is recognised by Schofield and Lea in their archaeological reconstruction of the Holy Trinity Priory, Aldgate. Schofield and Lea make frequent reference to documentary records to supplement the surviving archaeological evidence.[89] Documentary records are the next source to consider.

3.5 Records of property holding and management

Derek Keene and Vanessa Harding have observed that details of property holding and management in London become numerous after 1500, with the increasing survival of city livery company and parish archives. These record 'the names of tenants and the sums of rent paid and from circa 1550 onwards the records of the deliberations of corporate bodies on the management of their holdings are increasingly informative. The great expansion of the city in the late sixteenth and early seventeenth centuries caused many landlords to have detailed surveys made of the value and structural character of their properties.'[90] Some of these surveys included the production of floor plans. As these plans were produced as part of property holding and management, it is considered appropriate to examine them in this section of the chapter even though it could be argued that they should be included under the heading 'pictorial' (section 3.3 of this Chapter).

Ground floor plans are critical in the reconstruction of the built environment but as Schofield has noted, there appear to be very few of these in London before the end of the sixteenth century and they were generally restricted to the outline of the site only.[91] As property portfolios began to increase following the Dissolution and Reformation, however, some landlords saw the benefits of drawn surveys. In 1586 the

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[89] Schofield and Lea, *Holy Trinity Priory*, pp. 30,98,113,126,127, and 185.

[90] Keene and Harding, *Sources for Property Holding* (London Record Society, 1985) pp. xi –xii.

[91] Schofield, *Medieval London Houses*, p.4.

City representatives were negotiating with Lord Thomas Howard about the purchase of the Holy Trinity Priory in Aldgate, which occurred in 1592.[92] It was during this negotiation that John Symonds drew floor plans. Symonds was a joiner by trade but evidently also skilled in masonry, and made several surveys of mansions.[93] Along with his contemporaries John Thorpe and Simon Basil, he used rulers to draw lines, and included window openings and sometimes vaulting arrangements. Showing window openings is particularly useful for assessing the provision of natural lighting and ventilation in Chapter 6 of this thesis.

The drawings of Symonds, Thorpe and Basil often included upper floor plans. It would seem that the reconstruction of the church buildings of Holy Trinity Priory in Aldgate must have been a relatively straight forward task for Richard Lea, thanks to the amount of information included in the survey drawings made by Symonds.[94] An archaeological excavation of the Holy Trinity Priory has, however, revealed anomalies. Schofield notes that Symonds has omitted some obvious details which leads us to question what the draughtsman was intending to portray. Schofield suspects that Symonds's priority was to illustrate in detail the full extent of the former monastic building. This therefore conflicted with illustrating the conversion of the Holy Trinity to residential accommodation.[95]

Christ's Hospital and the Clothworkers' company commissioned another 'type' of surveyor called Ralph Treswell in the early seventeenth century. Treswell was originally a Painter-Stainer by trade. In contrast to Symonds his plans were drawn freehand but are nevertheless important and useful for providing a wide range of building plans, which are otherwise not available in quantity for London. He is an important source used by Guillery in the previously mentioned comparable analysis of plans of former buildings in the city centre and remaining structures in the early modern suburbs. Treswell's commissions for Christ's Hospital took place between 1607-11 and in 1612 for the Clothworkers'. His depiction of the layouts of rooms

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[92] John Schofield and Richard Lea, *Holy Trinity Priory, p*.21.

[93] Ibid.

[94] Ibid. pp. 24-26.

[95] Ibid. p.171.

combined live-work buildings, and the position of fireplaces, privies and stairs assists the forensic reconstruction of housing.[96]

It could be argued that Treswell was attempting to produce attractive plans as well as convey information. It is not certain that this led to trade-offs in terms of the information provided. Another contrast with Symonds *et al* was that Treswell only illustrated the ground floor plan. It appears that Treswell's remit was only to show the extent of the building but reference to upper storeys is included in the accompanying text.[97] Schofield has observed five points that need to be considered in relying upon Treswell as a source: first, the measurements in the accompanying texts are not exact enough to detect walls on any floor above the ground; second, with regard to the upper floors, we cannot tell how much of each floor jettied to the front and how much to the back; third, Treswell also omitted any reference to passages or other spaces between rooms; fourth, was the omission of the storey height; fifth, windows are rarely shown.[98]

In terms of the layout of the upper floors in the houses surveyed by Treswell, Schofield suggests that it is probably only safe to 'experiment' with smallest houses. Reconstruction can only proceed on the tenuous assumption that the first floor partitions generally coincided with ground floor partitions that are shown on the plan. Experience with standing buildings suggests that this can be assumed only for load-bearing or party walls, that is, not those in the middle of Treswell's buildings, such as the partition between two rooms, from which measurements are calculated to create a jetty on the first and upper floors. Schofield concludes it is likely that houses one room deep with a back against a property boundary could only extend towards the front. If we follow these guidelines, many of the houses surveyed seem to be jettied on the first and higher floors.[99] Although the height of each storey was lacking, statistics concerning the size of rooms, the numbers of rooms in each tenancy, the

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[96] Schofield, *The London Surveys of Ralph Treswell.*

[97] Ibid. p.10.

[98] Schofield, *The London Surveys of Ralph* Treswell, pp.28-29.

[99] Ibid.

proportion that were heated, and the proportions of ground space covered by buildings or cellared can be calculated.

In 1617 another surveyor produced plans of a building known as the White Bear, in Cheapside. The property was owned by Eton College and the plans specified measurements and the names of the tenants, including the name of John Milton's father.[100] Spelt as the 'White Beare' in the archives[101] the plans and accompanying survey were reproduced by archivists and author Noel Blakiston.[102] The plans show a rectangular block with a street range of four storeys on cellars. The walls to the cellars are thick brickwork with a small number of brick walls at ground floor level, separating a warehouse to the rear from two shops facing Bread Street, and another brick wall dividing two small shops on the same side street. The rest of the walls would appear to be of timber-frame construction and there is reference to two flat roof structures or 'leads' on the top two floors. The 'lead' on the third floor appears to have been used as a roof terrace for one of the tenants.[103]

Following the Great Fire of London, records of property holding were vital in assisting the City's three appointed Surveyors in plotting and staking-out the foundations prior to rebuilding.[104] Where such records were not available then the surveyors looked to site evidence and questioned interested parties. The Surveyors recorded dimensions and the position of foundations in their 'foundation books'. These often included schematic plans or a single line representing the position and length of the foundations. The surveyors were instructed by the City Lands Committee to deliver their notebooks to the Comptroller so that the information could

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[100] Public Record Office Vol. XVI http://www.nationalarchives.gov.uk/nra/onlinelists/GB1472%20ECR_24.pdf, pp. 328-332, date accessed 15 September 2013.

[101] Ibid.

[102] Noel Blakiston, 'Milton's Birthplace', *London Topographical Record,* **19,** pp.1-9.

[103] A version of these plans is illustrated in Schofield, *Medieval London Houses,* p.173.

[104] Peter Mills and John Oliver, *The Survey of Building Sites in the City of London after the Great Fire of 1666,* in P.E. Jones and T.F. Reddaway (eds.) (London Topographical Society, No.103), p.xvi.

be transcribed into their records. Apparently the City was anxious to have this information as an insurance against possible future disputes on boundaries.[105]

The foundation plans formed the basis of the foundation certificates to be issued to the property owners or tenants but the drawings were never meant for public consumption. The drawings were in the form of line drawings and Jones and Reddaway have suggested that the plans are a potential source for those 'working in the field of London topography.' The descriptions or plans for most foundations include the names of the owners or occupiers of adjacent sites and thereby link one property with another. Jones and Reddaway state that 'by means of the [their] index, and with much patience, the sequence of properties along each street might be compiled and plotted.'[106] Unfortunately a foundation as set out might not cover the whole site so that the adjacent measurements do not necessarily agree; also foundations to internal load-bearing walls are not shown, as this was not a requirement of the Surveyors. The schematic or line-drawings are also used in some lease plans as illustrated in figure 3.15 in the drawn survey by John Ward in 1692. It is therefore essential to take into account the background and intentions of all the surveyors when they produced their drawings for property holding purposes.

With regard to written documentation on the administration of property management, my research into the archives of the Goldsmiths has provided details on how the general running of the Company was moving slowly into greater professionalism from the early 1500s; this included closer surveillance of houses, leases and repairs. [107] By the seventeenth century the accounts of the Goldsmiths list property management issues systematically, for example specifying planned surveillance or views on certain days, isolated emergency repairs[108] and extensive repairs to a 'ruinous tenement in Gutter Lane.'[109] Details of the properties and defects are, however, lacking and this could be due to the fact that by the mid sixteenth

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[105] Ibid. p.xviii

[106] Ibid. p.xxii

[107] The Goldsmiths' Company's Archives, *Court Book 1651-54*, p.54.

[108] Ibid. p.58

[109] Ibid. p.60.

century institutional landlords let property on leases that required the tenant to repair. It is surprising, however, that there appears to be a lack of reports on any tenants failing to meet these repairing obligations.

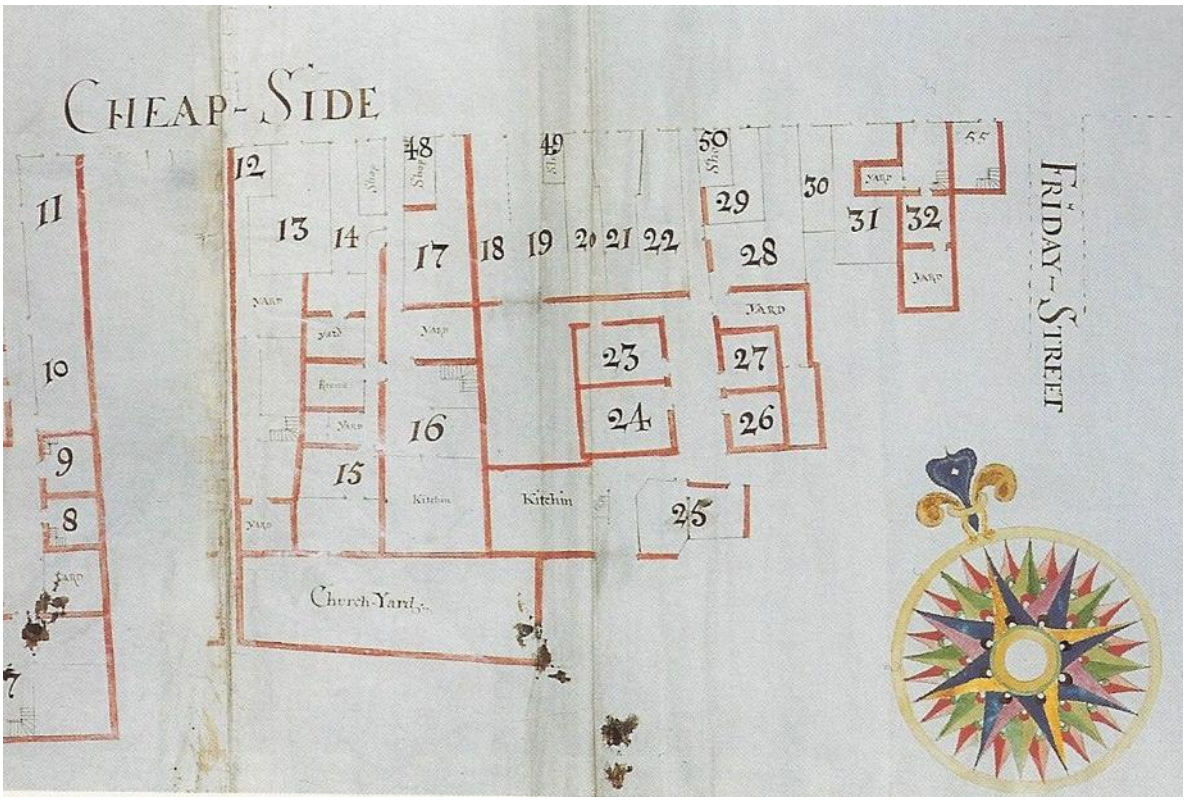

Fig. 3.15 Detail of a John Ward survey of 1692 showing Nos. 30-32 Cheapside belonging to the Goldsmiths' Company

The task at the outset of the research was to choose a detailed sample of records that could supplement and fill the gaps in the other sources. Rather than seek a wide range of primary sources, this thesis draws upon a detailed secondary source, compiled over a number of years, which offers advantages of scale. The *Cheapside Gazetteer* produced by Derek Keene and Vanessa Harding on the detailed property histories for five parishes in the central Cheapside area of London, has proved to be of great value.[110] It includes accounts and information about the people and buildings associated with the properties. It could be argued that this *Gazetteer* produces its own

[110] Keene and Harding, *Historical gazetteer of London before the Great Fire: Cheapside; parishes of All Hallows Honey Lane, St Martin Pomary, St Mary le Bow, St Mary Colechurch and St Pancras Soper Lane* (1987), URL: http://www.british-history.ac.uk/report.aspx?compid=8466. Date accessed: 24 March 2013.

form of 'stratigraphy', describing the order and position of buildings as they changed in plan, size and use from the twelfth to the late seventeenth century. The histories of these buildings place the function and performance of the sixteen- and seventeenth-century buildings in context. Accounts of how the properties were subdivided and extended are of value, particularly in the context of early modern building policies. Accounts are also given on the frequency of repairs and the nature of the defect is detailed. These repairs include defective chimneys, roofs, gutters, walls and decayed roof and floor timbers. Thus, data on the performance of timber framed and part timber and part masonry buildings is built up, which is a useful source for chapter 5. The *Gazetteer* is also a useful source on how the buildings were used and serviced, which is the focus of chapter 6. Detailed accounts of the water supply and storage are given, as well as the number of privies, windows and fireplaces. The *Gazetteer* broadens the scope of property ownership, detailing the histories of privately owned properties as well as those in the ownership of the City and Livery companies. Thus, a social topography within a very small but densely populated area is built-up. The different occupations of the users, in streets, lanes, and alleys are mapped. This is of value in considering variations in the quality of localised built environments and in developing the concept of 'social epidemiology' in the final chapter.

The study of the above records of property holding and management offers a fair idea of standard practice, procedures and attitudes to building practice and maintenance of structures in early modern London. The repair and maintenance was enforced by lease covenants. The *Gazetteer* makes references to leases, but a sample of those contained in the archives of the Goldsmiths' has also been examined.[111] These ordinary leases bound the lessee to keep the premises in good repair, and allowed the landlord to eject him if he failed to do so. The *Gazetteer* gives examples of repairing covenants being enforced. The decrees of the Fire Court make reference to lease provisions in the aftermath of the Great Fire.[112] P.E. Jones confirms that 'leases in London at the time of the Fire commonly contained a covenant binding the

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[111] In the Goldsmiths' Archives is a document in a binder, titled *Extract of Leases 1650-1675.* This gives descriptions of individual properties, schedules of accommodation and specifies the length of the lease and the rent.

[112] Philip E. Jones, *The Fire Court*, (William Clowes & Sons Ltd., 1966) Vols. 1and II

lessee at all time needful during the term to well and sufficiently sustain, maintain, uphold, repair and amend the premises and every part thereof (with oak and elm and not fir or deal), cause the pavements to be repaired and the privies to be cleaned together with all the fixtures belonging to the landlord'.[113]

Mention has been made of the surveillance or views forming a key part of property management but views were also required to deal with disputes between landlords, tenants and particularly neighbours and to enforce the provisions of statutes and environmental law; this has broadened the analysis of the research into building defects and leads to the final source.

3.6 Viewers and Surveyors

The sources considered up to this point have provided evidence of how the buildings of early modern London were constructed and maintained; the last source also gives some indications as to use and inhabitation. From these sources we may hypothesise how well the structures functioned and performed but the most informed way of making such an assessment is the professional building survey. An early modern version of such a survey was the 'view'. It has been shown that the landlords of early modern London recognised the importance of surveying their own properties for the purpose of ensuring that the building was free from defects and functioning properly. Identifying defects and specifying remedies was part of good property management. It has already been noted that landlords had an interest in maintaining the quality of their inner-city premises in order to uphold the rents.[114] From these property management-based views the responsibility for repairs would be determined, but views were also undertaken in a different context.

For almost five hundred years, the City of London appointed master masons and carpenters to view properties that were the subject of a dispute.[115] Janet Loengard has provided a detailed history of the institution of the Viewers and it is not intended

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[113] Ibid., Vol.1, p. vii.

[114] Harding 'Housing and Health', pp.25-6.

[115] For this and what follows on the pre-fire buildings I am indebted to Janet Loengard's book, *London Viewers and their Certificates, 1508-1558* (London Record Society, 1989) and also personal communications with her on 26 June and 28 July 2008.

to repeat that information here. It is nevertheless important to note that commissioning a 'view' was a recourse open to citizens on payment of a fee, and that the essence was a site visit. Viewers were obliged to give a verdict on what they observed, but they could hedge their opinion with a caveat, especially where property rights were concerned. At any one time, there was a maximum of four viewers and the disputes pertaining to building defects they addressed could include: a chimney or wall about to collapse on a neighbour's property; a defective gutter causing damp ingress into an adjoining building; the contents of one man's privy spilling onto next door's land.

The master tradesmen appointed as Viewers are not to be confused with the Masters of the City Companies of Masons and Carpenters. The men appointed as Viewers had often gained experience as one of the City Artificers, mason, bricklayer, or carpenter, retained as contractors to the City.[116] Thus, during the first half of this study period at least, they were men at the top of their profession.[117] This provides currency to the Viewers as a significant source, particularly as they were the men on the ground, reporting first-hand on building defects. A City clerk often accompanied the Viewers on an inspection and this official would record on-site the findings of these master tradesmen, who were effectively performing the function of the assize jury. The findings would be recorded in a certificate and signed by each of the Viewers (see figure 3.16 below); copies were given to the parties and the duplicates are now stored in great numbers in the London Metropolitan Archives. The aim of the 'view', in the context of a dispute between neighbours, was to establish the facts and liabilities before the aggrieved person took legal action.

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[116] Jones and Reddaway (eds.), *The Surveys of Building Sites*, p.x.

[117] Loengard, *London Viewers*, p.xvi.

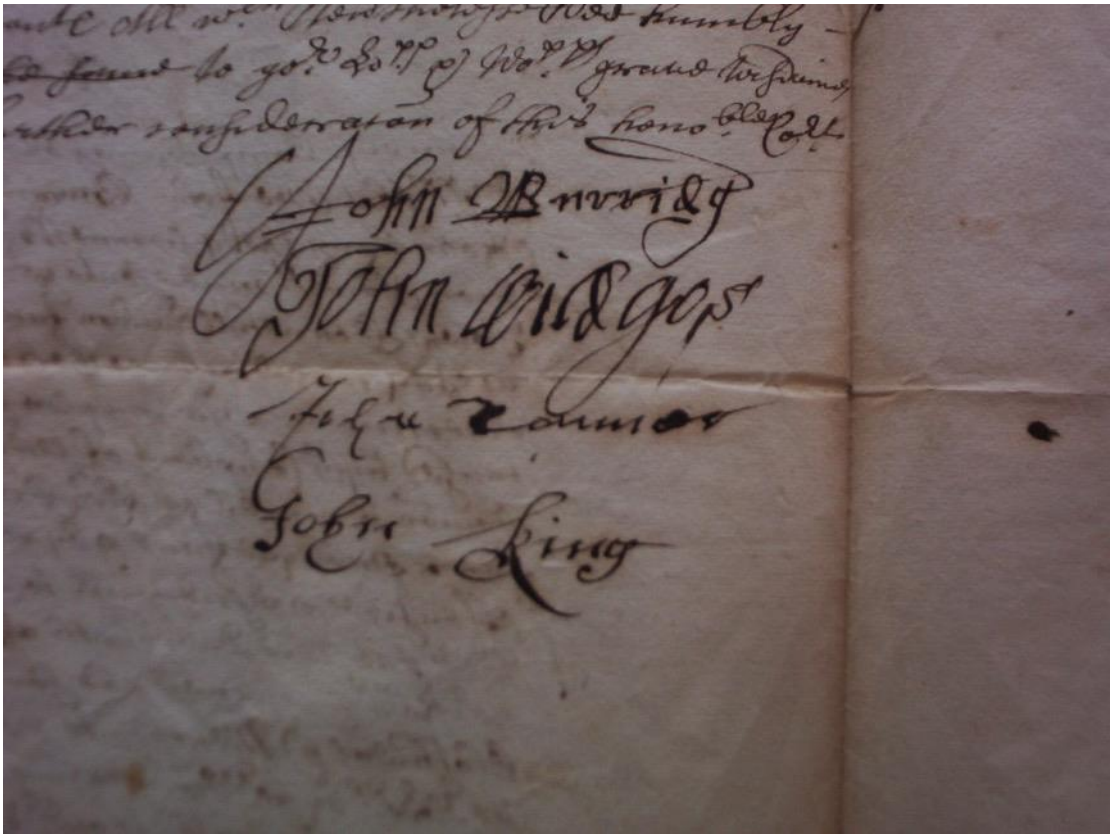

Figure 3.16. The signatures of Four Viewers on a certificate, LMA CO/SJ/27/469/92.7, dated October 1667.

For the purposes of this thesis, the findings of the Viewers are of great value, identifying specific building defects which may have contributed to respiratory illnesses and enteric disease; for example, there are a significant number of certificates relating to damp penetration in buildings, defective privies and wells and these have been entered into the Building Pathology Database (see Appendix B). As is noted in Chapters 4 and 6, respiratory and enteric diseases are influenced in varying degrees by daylight and ventilation, and here the Viewers had an important influence. In dealing with the mutually contradictory rights to privacy and light, they were able to order the demolition, reduction in height and alteration of buildings.

The Great Fire precipitated change under Section II of the Rebuilding Act of 1667, which stated that in order to prevent the construction of ‘irregular Buildings,’ that is, timber-framed structures, the Mayor, Aldermen and Common Council were to ‘elect nominate and appoint one or more discreet and intelligent person or persons in

the Art of Building to be the Surveyors or Supervisors.'[118] Why the Viewers were not appointed under this delegated legislation is unclear.[119] It has been noted that they were recording technical facts on-site, but the Viewers were also applying law in the form of binding custom. This would have suggested that the Viewers were well qualified for the role in the reconstruction of the city centre. Loengard has noted, however, some hint of decline in the office into the Stuart period where the 'viewers were operating under a narrowed mandate and greater supervision or they had lost the self-confidence of their predecessors, for their certificates are more deferential in tone and show little willingness to venture beyond technical comments based on professional expertise.'[120]

This observation does not devalue the Viewers as a source, for it is their technical comments that are of importance in recording building defects. Loengard has also noted that that the nature of the Viewers' activities in the early 1600s remained largely unchanged from what it had been in the earlier half of the sixteenth century, such as the appointment of a maximum of four Viewers, despite the fact that building in London was booming. Loengard suggests that 'four men, even if diligent and experienced, could do only so much.'[121] This implies that any failure of the Viewers to address building disputes and defects was not because they were lacking technical ability but they were under-resourced. To confirm the technical standing of the Viewers, one of their number, Peter Mills, was appointed to the higher office of a City Surveyor under the Rebuilding Act of 1667.

Jones and Reddaway have suggested that it was the administration of the Viewers, rather than the quality of the individuals that was not up to the task of supervising the rebuilding the city centre.[122] And yet if under-resourcing was the issue, then this is not explained by the appointment of only three Surveyors; Robert

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[118] Charles II, 1666: An Act for rebuilding the Citty of London.', *Statutes of the Realm: volume 5: 1628-80* (1819), pp. 603-612. URL: http://www.british-history.ac.uk/report.aspx?compid=47390 Date accessed 29 March 2013.

[119] As will be noted later, the City did not demand a full-time commitment to the role of City Surveyor.

[120] Loengard, *London Viewers*, p.xiii.

[121] Ibid. p. xiii.

[122] Jones and Reddaway, *The Surveys of Building Sites*, xi.

Hooke and John Oliver joined Peter Mills in 1667. Robert Hooke (1635-1703), the scientist, was one of the most gifted men of his age and has been the subject of much recent study.[123] Significantly he was co-author of the Rebuilding Act, the statute he was aiming to enforce as an appointed surveyor. Reading the Act it may be seen as an enabling document, addressing the importance of the controlled and expeditious rebuilding of the city centre, whilst recognising that the statute could not legislate for every situation that may be encountered on-site. This theme is very much reflected in the certificates produced by Hooke when advising and directing the rebuilding of terraced houses at varying times and on differing gradients. For example, on the 4th December 1669 Hooke headed an investigation by the three Surveyors into a dispute in Knight Rider Street, where he observed 'Mr Conway formerly had divers lights through a certain brick wall onto the ground of Mr Knowles.' The latter had rebuilt the wall cutting off the 'ancient lights' to Mr Conway. Hooke reported that 'Upon discoursing the business with both parties we find that they may both be accommodated.' Conway and Knowles 'confessed' or agreed that the wall was a party wall, and in accordance with the 'Act of Parlm.' they should share the cost of its reconstruction. To rebuild the wall to its pre-Fire specification, however, did not suit the requirements of Knowles and Conway agreed to 'dispense with light he formerly had' on the understanding that Knowles would 'pay the majority' of the costs of re-construction.[124]

John Oliver (circa1616/17-1701) was in attendance on this view, and has been described as 'the citizen of many talents.'[125] Jones and Reddaway have observed that Oliver's interests were so varied that they have led to some writers suggesting there were two men of the same name.[126] His interest extended to surveying, architecture, building, and glass painting. He was a municipal councillor, a parish officer and a

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[123] For the most recent accounts see Stephen Inwood, *The Man who knew too Much* (Pan MacMillian, 2002) Lisa Jardine, *The Curious Life of Robert Hooke: The Man who Measured London* (London 2003); Michael Cooper *Robert Hooke*.

[124] LMA COL/SJ/27/470/93.46 AND LTS VOL.III.60

[125] Jones and Reddaway *The surveys of Building sites*, Vol. I, p.xxxii.

[126] Ibid., p.xxx.

public-spirited citizen.[127] There are records, however, of the City proposing the appointment of the glazier John Oliver on 27 February 1667 to be a Surveyor. He asked to be excused but offered to assist the ailing Peter Mills gratis.[128] As noted earlier Peter Mills (1598-1670) was formerly a Viewer, appointed after gaining experience as City Bricklayer, having been admitted to this position in 1643. He served as a Viewer from 1644 and surrendered this office in 1657, presumably to pursue his interest as a builder, or what would be referred to today as a property developer.[129]

Jones and Reddaway recognised that Hooke, Oliver and Mills did almost all that a modern staff of town planners and valuers would do.[130] This observation outlines the wide ranging duties of the Surveyors; Jones and Reddaway could also have added that these three Surveyors were undertaking the equivalent role of modern building regulation officers. The previously mentioned records of foundation surveys by Mills and Oliver, collated and published by Jones and Reddaway represent only a small part of the City Surveyors' work, and inevitably their books contain occasional notes on their other activities.'[131] The Orders of the Common Council of 29 April 1667 specified other responsibilities stating that all persons should 'observe the directions of the surveyors concerning the superstructure to be erected on the foundations' and the surveyors were instructed to 'take special care that the breastsummers of houses should range at an equal height, that the breaks should only be made at their direction and that ornaments and projections on the front of buildings should be of rubbed brick'.[132]

Thus, the Surveyors were in the front-line of the rebuilding of London's city centre. Mills twice reminded himself of the scantlings of timber required by the

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[127] Jones and Reddaway *The surveys of Building sites,* Vol. I, p.xxxi.

[128] Corporation of London Records Office Journal 46.f.147r, dated 27 February 1667.

[129] Ibid., pp. x, xi and xxvii.

[130] Ibid., p.ix.

[131] Ibid., Volumes II-V.

[132] Corporation of London Records Office Journal 46, ff. 151r-2r, dated 29 April 1667.

statute [133] and the foundation books contain sufficient evidence to show that the surveyors did indeed inspect the superstructures. Mills notes an irregular building in Bishops Court with walls too thin, floors too low and timbers too small and elsewhere insufficient brickwork and timber partitions.[134] Four houses in Mincing Lane were pulled down because the back parts were built of timber.[135] In St. Bartholomews Oliver found cellars and chimneys of faulty construction, bad mortar and lintels of fir, and in Blackfriars a roof framed without principal rafters.[136] Elsewhere he noted storeys too low, joists too far apart, walls too thin and cracked, a roof fir and generally poor workmanship.[137]

The extent of their work in this field, only hinted at in *The Survey of Building Sites* is given in greater detail in the London Metropolitan Archives.[138] Here the certificates of the Viewers and Surveyors are mixed together, not least because there are many instances where the two offices were involved in the same view (see figure 3.17 below). The City Viewers Joseph Titcombe and George Hatton took part in the views with Hooke and Oliver. Titcombe and Hatton were two of the four City Viewers who in the 1680s were increasingly involved when matters to be viewed were no longer exclusively related to new buildings.[139] Thus, in the 1670s there was some division of labour between the Surveyors and Viewers. The Surveyors plotted and certified foundations and handled matters concerning new construction alleged to be 'irregular' under the Building Acts while the Viewers dealt with the complaints made by private parties or on behalf of the City, resulting from such building, for example lights stopped up, encroachment, and with public nuisances such as stairs obstructed by rubbish. The division of the roles between the Surveyors and Viewers, however, was not consistent.

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[133]Jones and Reddaway *The surveys of Building sites,* Vol.I, 6v.64

[134] Ibid. II.14, 62, 142v; III.53

[135] Ibid. II. 145.

[136] Ibid. IV.80, 194

[137] Ibid. V.68,89,102v, 105,151

[138] COL/SJ/27/469-Box 92; COL/SJ/27470- Box 93 and COL/SJ/27471, Volumes I-III.

[139] LMA COL/SJ/27/471. Vol.III.

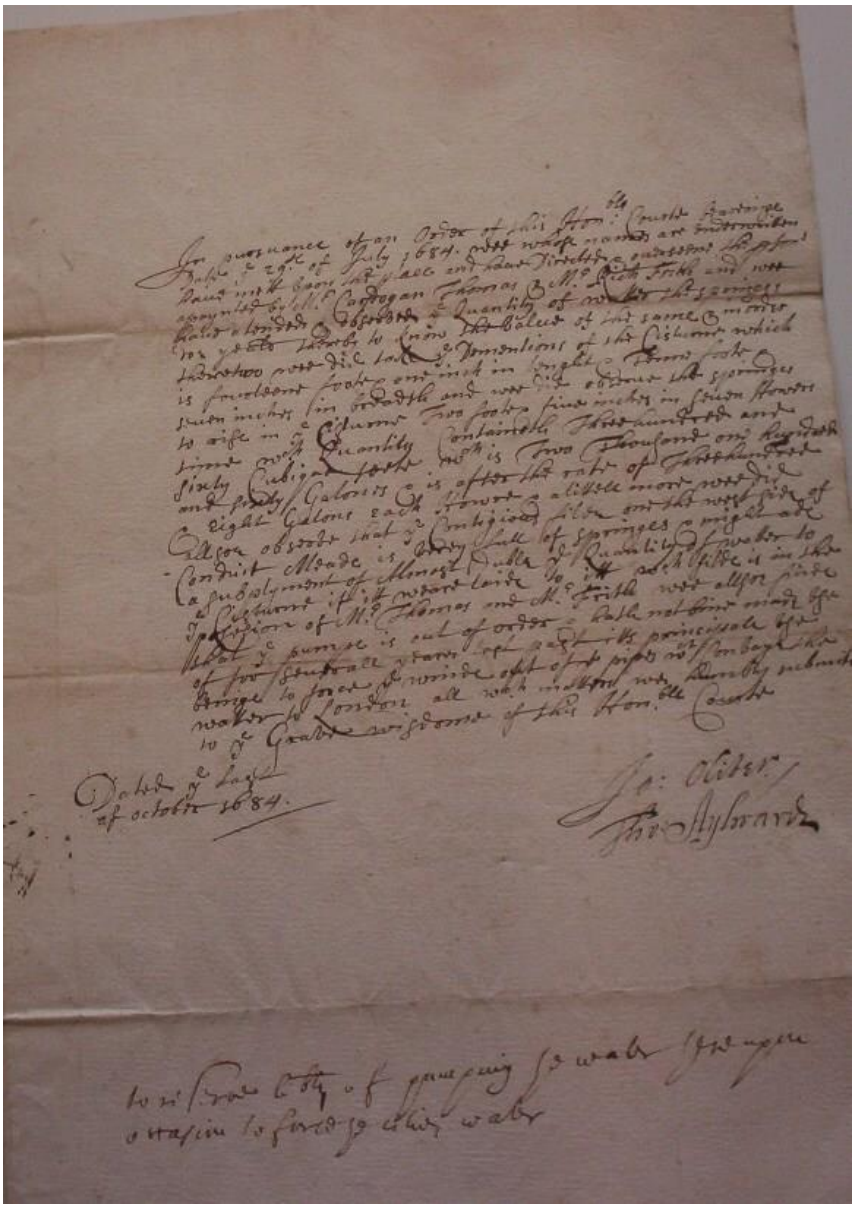

Figure 3.17. A certificate signed by City Surveyor John Oliver and a Viewer, Thomas Aylwood, October 1684.

Although it appears that Hooke did not submit his site notes (so that his inspections of the foundations are not included in the published *Survey of Building Sites*), it is clear from the certificates in the London Metropolitan Archives that he took the dominant role in all 500 or more post-Fire views in which he was involved. This is evident from the fact that every existing original report of a view in which he

took part was written by him.[140] Although a strict hierarchy was observed in the order of signatures on a report, that is Mills, Hooke and Oliver, according to the date of their first appointments by the City, Hooke always wrote the report, even when Peter Mills, his senior was also involved. Hooke was the prominent surveyor, doing more than anyone to ensure that the location, structure and form of new houses were regular, legal and in more congenial surroundings than they were before the Fire.

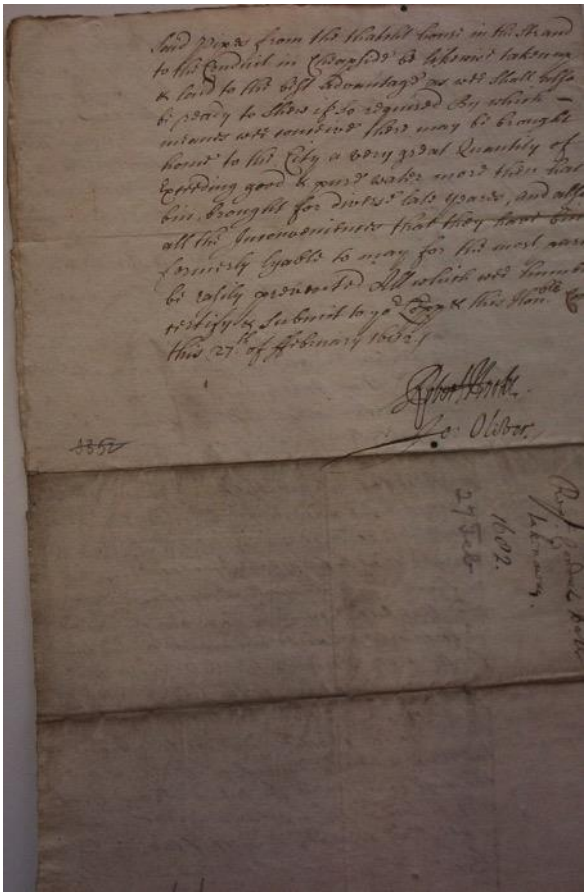

Figure 3.18. A certificate signed by Hooke and Oliver, 27 February 1682.

It is also apparent, however, from the post-Fire certificates that the second Rebuilding Act of 1670, stating the statutory requirement for the foundations to be set out by the surveyors, was retrospective.[141] Sections XI and XII received Royal Assent

[140] Also confirmed by Cooper, *Robert Hooke*, p.154.

[141] Charles II, 1670: An Additionall, Act for the rebuilding of the Citty of London, uniteing of Parishes and rebuilding of the Cathedrall and Parochiall Churches within the said City.', *Statutes of the Realm:*

on 11 April 1670 and by that time building operations were already taking place across the city centre. The problems resulting from this are recorded in the majority of the post-Fire certificates of the Surveyors where many buildings, already built or nearing completion, are recorded as being 'Irregular and Contrary to the Acts of Parliament for rebuilding the Citty.'[142] Clearly these were the cases that were discovered, often accidentally, when the Surveyor was inspecting another property. There is a strong case to argue that owing to lack of appropriate resources, many defects remained undetected or accounted for later building failures. What is not in doubt, in reading the certificates of the Surveyors, is their clarity of thought and description in the problems encountered in the rebuilding of the city centre.

The lack of resources in enforcing building policy appears to become even more acute before this study period ended as witnessed by the decline in the offices of the Viewers and Surveyors in the 1690s. Loengard has noted that for reasons which are not stated in the Repertories entries, the Mayor and Aldermen admitted a glazier as Viewer in December 1679 and, more startling still, a weaver in October 1685 and a glover in April 1695: [The] 'Choice of such men must have diminished the viewers' authority and in fact the Repertories entries give the impression that the post had become more or less a sinecure.'[143] It is possible, however, that although the apparent trades of these individuals was stated, these may have been indications of company membership. It is striking, however, that the Carpenters and Mason Companies appear to have lost control of the posts. With regard to resourcing the office of City Surveyors it is significant that a replacement for Peter Mills was not appointed after his death in 1670 as only the names of Hooke and Oliver appear on the certificates from that year onwards. Hooke's last view took place in 1691.[144] What happened after the departure of Hooke and Oliver is not evident. Robert Hooke died at Gresham College in March 1703. There is, apparently, no record of the death of John Oliver who assisted Wren in the rebuilding of St. Pauls. After 1700 the records of the City's

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volume 5: 1628-80 (1819), pp. 665-682. URL: http://www.british-history.ac.uk/report.aspx?compid=47419 Date accessed: 29 March 2013.

[142] For example LMA COL/SJ/27/470/93.126/Oct 5 1687.

[143] Loengard *London Viewers*, p.xiii.

[144] Corporation of London Records Office, Miscellaneous MS 93.129, dated 6 November 1691.

Viewers and Surveyors cease although the Rebuilding Act continued in operation until Building Act of 1774.[145]

Thus, for all but the last thirty years of the study period, the Viewers and Surveyors provide a considerable quantity of data indicating defects in the built environment of early modern London. The history of building regulation in London suggests that beyond 1690 the buildings continued to be built in the same way, with limited enforcement of statutory requirements.[146]

3.7 Conclusion

The aim of this chapter has been to consider the sources that would enable an historic reconstruction of a built environment that may have contributed to enteric and respiratory illnesses. What has become apparent in the critique of all these sources is their fragmented nature, a metaphor repeated throughout this chapter. Although map-views were produced for a limited domestic market as objects of display and ornament, the themes illustrated in this source is the high density of building and little open space. This theme is reinforced in the panoramas and two-dimensional maps but the former gives greater detail in respect of the form and height of buildings, whereas the latter depicts variations in the width of streets, lanes, yards and alleys. The selected pictorial and photographic sources illustrate more detail of building form but across a broader section of society, providing some clues to inherent defects as well the neglect of the fabric. The relatively small number of remaining buildings, supplemented by archaeological records, provides visual evidence in considering the style, function and performance of the structures and services. Caution is required in the interpretation of these physical remains as the buildings have been altered and repaired over many years. Paradoxically, it is the written documentary sources of property management and the reports of the Viewers and Surveyors that produces a more tangible mental image of the users of the buildings, pollution of water supplies, leaking privies, poor quality lighting and ventilation as well as damp ingress into the buildings. It is apparent, however, that each of the sources has their own limitations

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[145] CC Knowles and P.H Pitt, *The History of Building* regulation in London (Architectural Press, 1972), p.49.

[146] Ibid.

and it is their collective application that is of great value in reconstructing the houses and their defects.

PART II: Building Pathology Analysis

Chapter 4

Building policies: An Intervention Study

This is the first of three Chapters in the building pathology analysis and will consider the possibility that failures in building policies contributed to unhealthy housing in early modern London. The failure of statutory requirements was identified in the opening Chapter as one of the causes of a building defect that may manifest itself in a structure, fabric or building services. It will be seen that building policies were pursued by more than one source of law in early modern London, and this in itself may have been a cause in the failure to regulate building practice.

According to Professor Eric Mood, in almost all of the more developed countries, recognition has been given to the relationship of the quality of housing to the health of the occupants.[1] There is a considerable wealth of knowledge that identify the conditions of housing that should be provided in order that a dwelling may be considered to be 'healthful.'[2] In Chapter 1 'healthful' was defined as 'serving to promote health of body and mind'[3] and attention was drawn to the various research studies by the World Health Organization *et al* on those conditions which must be met to provide 'healthful housing'. In the context of this thesis two fundamentals of healthful housing were identified in the opening Chapter: first was the prevention or limitation of the transmission of pathogenic agents; the second fundamental concerned those conditions that must be provided to fulfill the physiological requirements of humans, particularly respiratory illnesses linked with cold, dark and damp buildings.

In the modern era healthful housing is sought through intervention by statutory authorities, which make demands on those who design, build, manage, repair, maintain and occupy buildings.[4] Any failures to meet these demands may undermine the two fundamentals of healthful housing and potentially expose the

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[1] Eric Mood, 'Fundamentals of healthful housing', p.303.

[2] Ibid.

[3] Ibid.

[4] Watt, *Building Pathology*, p.19.

occupants to building-related illnesses that appear to have a close correlation to the *Chronical* diseases identified by John Graunt.[5] Some of these diseases were clearly infectious and therefore of a pathogenic nature; others appear to relate to physiological disorders, and were comparatively stable from year to year, 'a constant strong undercurrent.'[6] Consideration is therefore required of any constant building defects that may have contributed to these two particular diseases.

This inquiry into failings in the statutory requirements starts with the sources and administration of law pertaining to buildings in early modern London and the extent this addressed enteric and airborne diseases as well as physiological disorders. As noted in the opening Chapter, dampness has been recognised as an agent in the spread of disease and an assessment will be made in the final part of this Chapter of the extent damp proofing was addressed through statutory requirements.

4.1 The sources and administration of building policy

The main statutory requirements that would address the two fundamentals of healthful housing in the modern era are the Town Planning Act 1990 and Building Regulations 2000. The current Town Planning Act aims to ensure that buildings are constructed in the correct place and to a defined density. Prohibition or restriction on construction is known as 'Planning Control' and is one of two key elements of modern town planning. The second and more creative element of modern town planning aims to balance the developments a city needs, for example new homes, factories, offices and schools, with the need to protect and improve the environment. This balance is essential to ensure that development and growth are environmentally sustainable, that is, meeting the needs of the present without affecting the ability of future generations to meet their own needs. Planning is also concerned with the size, shape and appearance of buildings.[7] The Building Regulations aim to control how a building is constructed, as well as securing the health, safety and convenience of people in or about buildings, conserving fuel and power and preventing waste, undue

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[5] Graunt, *Natural and Political Observations*, p.16.

[6] Harding, 'Housing and Health' p.32.

[7] The Town and Country Planning Act 1990, HMSO http://www.hmso.gov.uk/acts/acts1990/Ukpga_19900008_en_1.htm

consumption, misuse and contamination of water.[8] Engaging *building pathology* in this study period requires an investigation into the early modern equivalents of these statutory requirements. Although the terms 'town planning' and 'building regulations' were not coined during the study period, we need to consider the extent to which the concepts were recognised and implemented in early modern London.

Some writers consider the Rebuilding Act of 1667, drafted in the aftermath of the Great Fire of London, was the first major town planning act in Britain but it also had elements which would be considered to be of a building regulation nature.[9] These assertions will be considered more fully in this Chapter but Daniel Defoe provided a generalised contemporary opinion of this particular statute in his *Tour through the Whole Island of Great Britain* (1724-26):

> It is true, that before the Fire of London the streets were narrow, and public edifices, as well as private, were crowded, and built closer to one another; for soon after the Fire, the king, by his proclamation, forbid all persons whatsoever, to go about to rebuild for a certain time, viz. till Parliament might regulate and direct the manner of building, and establish rules for adjusting every man's property, and yet might make order for a due enlarging of the streets, and appointing the manner of building, as well for beauty as the conveniency of the city, and for safety, in case of any future accident…[10]

The burnt section of London comprised mainly the city centre within and near the ancient walls. Rebuilding according to statutory requirements took approximately ten years[11] and Defoe appears to pose a 'before and after' comparison: 'How this has been regulated, how it was before, and how much better it is now, I leave to be judged, by comparing the old unburnt part of the city with the new.'[12] Defoe wrote with enthusiasm about the rebuilt area of the capital and therefore appears to be

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[8] The Building regulations 2000 HMSO http://www.hmso.gov.uk/acts/acts1990/Ukpga_19900008_en_1.htm

[9] Rasmussen, *The Unique City*, pp.93-114; Knowles and Pitt, *The History of Building Regulation*, pp.34-5; Guillery, *The Small House*, pp.48-9.

[10] Daniel Defoe, *A Tour through the Whole Island of Great Britain, 1724-26* Pat Rogers (ed.), (Harmondsworth, Penguin, 1971), p.102.

[11] Reddaway, *The Rebuilding of London*, p.284.

[12] Defoe, *A Tour*, p.103

expecting the reader to agree with his implied conclusion. We must also be aware of the caveat noted in Chapter 2 that a before and after comparison in an 'intervention study' may have little value for invariably it is difficult to disassociate benefit due to intervention from benefit due to the passage of time, however self-evident the benefit of intervention may seem.[13]

As will be discussed later, the Rebuilding Act of 1667 codified some elements of the City's local bye-laws or 'Customs' and royal proclamations; up until this point much of the law controlling building was from these different sources. There was also divided responsibility in terms of administering control over buildings. Despite London's growth from 1550, it continued to have two separate administrative centres: the Court of Common Council in the City, and from 1585 the Court of Burgesses at Westminster. Up until 1580, the 'ancient custom of the city of London'[14] was the main source of law pertaining to building administered within the Roman-medieval walls and the immediate extramural suburbs. The officers of the mayor's household might have performed a wide range of functions in the City's government, but they were too few to serve in anything more than a coordinating capacity.[15] Much was therefore left to the discretion of the local community. It was, however, only through representatives of the local community that the aldermen could hope to obtain knowledge of offences. In addition to their Christmas presentments the wardmote inquests were regularly instructed by the aldermen to give information on specific offences such as breaches of the assize.

According to Archer there was a 'withering in the functions of the wardmotes' in this period.[16] If presentments of the fifteenth century are compared with those of the sixteenth century, it is clear that the proportion of regulative offences with which they were dealing was declining, leaving most local nuisances as the most typical of the wardmote's concern.[17] The presentments to wardmotes pertaining to concerns and

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[13] Mant, 'Understanding the problems', p.12.

[14] This phrase is quoted in varying forms in the certificates of the Viewers, for example see *London Viewers* [C.112] 14 March 1552.

[15] Ian Archer, *The Pursuit of Stability*, p.63.

[16] Ibid. p.68.

[17] Ibid.

disagreements over buildings, however, appear to be lacking in property histories.[18] A relatively rapid response was required for many building offences and disputes and therefore could not necessarily wait until the December presentments. An individual, or the individuals in a corporate body, who felt wronged by a neighbour in a building dispute could commission the Viewers before taking other legal action. According to Loengard the grant of a view appears to have been a matter of course, as she has not seen any evidence that a request was denied.[19] The Letter Books and Miscellaneous Rolls and later the Repertories and Journals provide records of settlement of private disputes between neighbours, albeit disputes which City courts might be called upon to decide. There was also a more public side to Viewers' duties; from early on, they were to report nuisances in which the City had an interest.[20]

Outside the City liberties and Westminster, the Middlesex Justices of the Peace (the royal representatives) were responsible, either collectively or as individuals, for law and order. During the same period building codes were enforced in Paris by building inspectors or 'masters of works.' This official had existed in Paris since medieval times, and the inspectors were, like the London Viewers, members of artisan guilds.[21] In London, proclamations and statutes were used to augment or replace certain Customs of the City; during this study period, the area over which control was sought varied from between two and ten miles from the city gates.[22] Statutory requirements were therefore just one of four areas of law invoked to control building in early modern London. Local by-laws or Custom, common law and royal proclamations were the driving force of building policy in the early part of the study period, and these have been given the generic term 'environmental law.'[23] As we shall see, some elements of environmental law were incorporated into statutes later

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[18] There is only one reference in *The Cheapside Gazetteer* and this relates to a much earlier period, St Mary le Bow 104/6 (*c*. 1420-2).

[19] Loengard, *London Viewers*,p.xxi.

[20] Ibid. xxiii.

[21] Orest Ranum, *Paris in The Age of Absolutism* (Indiana University Press, 1979), p.104.

[22] As is noted below, these distances varied between different proclamations and statutes during the study period.

[23] T. G. Barnes,'The Prerogative and Environmental Control'.

into the study period. Thomas Barnes considers that this process did not go far enough, and this represented a significant failure in building policy; [24] this together with other possible shortcomings is now considered in the context of enteric and airborne diseases and physiological disorders.

4.2 Building policies and enteric disease

As noted in Chapter 1, deaths through enteric diseases are quite prominent in the Bills of Mortality.[25] The lack of adequate sanitation accounts for many enteric diseases spread through pathogens and this is recognised in the requirements of the modern Building Regulations.[26] In the early modern context, Vanessa Harding has commented that the precise location of mortality pertaining to enteric disease is difficult to confirm.[27] Consideration of water and sanitation provisions in different areas of London is required and whether these were addressed through building policies.

Modern studies of enteric diseases afflicting occupants of dwellings have identified five basic conditions of housing that must be fulfilled as preventative measures:

- a safe, adequate, potable and palatable water supply which is available to each dwelling under pressure;
- sanitary methods for the collection and disposal of excreta and the prevention of faecal pollution of ground and surface-water supplies;
- sanitary collection, storage and disposal of refuse and other solid wastes;
- prevention of access into dwelling units of insect vectors of human disease;
- freedom within the dwelling from rodents, vermin and other than animals; sanitary provision for the proper storage of milk and other food stuffs. [28]

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[24] Ibid. p.1357.

[25] Harding, 'Housing and Health,' p.37.

[26] *Building Regulations 2000: Part G, Hygiene, Part H, drainage and waste disposal.*

[27] Harding, 'Housing and Health' p.37; see also chapter 7 of this thesis.

[28] Mood, 'Fundamentals of Healthful Housing', p.306.

An additional condition that must also be considered in the early modern context relates to the collection and disposal of rainwater. There was no early modern building policy requirement pertaining to the safe and adequate collection of rainwater for drinking purposes in London but Custom, and eventually statutes, specified its collection and disposal to address public and private nuisances. The apparent disregard of the sanitary collection of rainwater inevitably led to its pollution into 'waste' water and was treated as a sanitation issue during the sixteenth and seventeenth centuries. The disposal of wastewater in the modern Building Regulations is placed under the same category as the disposal of excrement [29] and accordingly is considered here under the same sub-section dealing in sanitary methods for the collection and disposal of excreta.

It could be argued at the outset that the above conditions were largely unachievable in early modern London but it is noted that these 'basic' conditions have been identified in the modern era in the context of addressing the spread of enteric diseases in 'undeveloped urban communities.'[30] The above five basic conditions provide a framework against which an analyses can be made on variations in the spread of enteric complaints.

4.2.i Water Supply

In order to understand more fully the causal system of enteric diseases pertaining to the consumption of water within dwellings, we first need to investigate the source and quality before it reached the occupants. Stow describes how there was a free supply within close proximity for most Londoners in the early part of this study period.[31] In addition to the Thames, Landers suggests that a series of shallow wells served the local requirements of many poorer districts,[32] but as is noted in Chapter 6, wells were

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[29] *Building Regulations 2000: Part H.*

[30] Professor Mood has given accounts of migratory labour camps in California and poor quality housing in Georgia, U.S.A in the 1950s, and housing in Venezuela in the 1960s in 'Fundamentals of Healthful Housing' p.307.

[31] John Stow, *A Survey of London* (London, reprinted 1912), p.360.

[32] Landers, *Death and the Metropolis*, p.70.

still in use in the wealthier city centre just prior to the Great Fire. London's city centre had a number of public fountains, known as conduits, which were supplied with water brought in lead pipes from springs in out-lying suburbs. Treswell's drawing of 1585 of St. Michael le Querne, at the west end of Cheapside, illustrates the water-pipes leading to and from the 'little conduit' as well as conical containers belonging to the water bearers.[33] As the population grew, new conduits were erected (ultimately there were sixteen), but the wells became contaminated or began to dry up, and could not keep pace with increasing demand.[34]

In 1544, the City was empowered by Act of Parliament to bring water from springs at Hampstead. This seems to have been the first private Act of Parliament giving a local authority compulsory powers to enter privately owned land and lay pipes, providing for compensation, and prescribing penalties for resistance to the corporation's servants. Apart from an unsuccessful attempt in 1589, however, the powers conferred by the act of 1544 do not seem to have been exercised.[35] Thus, schemes for making more water available to Londoners in the later sixteenth century once more involved recourse to the Thames. There is clear evidence of a high demand for the Thames as a source if consideration is given to the investment into the construction of water-wheel pump under the first arch of London Bridge in 1581 and the £1,000 spent on Bulmer's pump and water tower at Queenhithe in 1593.[36] It would seem that even by the late 1660s Thames water was supplied through a number of conduits and to low lying districts of the city centre by the London Bridge Waterworks pumping engine.[37] The Rebuilding Act of 1667 also specified that Thomas Morris's water-house was to 'be rebuilt upon the place it formerly stood with

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[33] Treswell, *The London Surveys*, p.23.The water bearers provided a service to individual dwellings; it is possible they also collected water from rivers, including the Thames. This is considered in more detail in chapter 6.

[34] J.W. Gough, *Sir Hugh Myddleton: Entrepreneur and Engineer* (Oxford, 1964), p.24.

[35] Ibid.

[36] Rosemary Weinstein, 'New urban demands in early modern London', *Journal of Medical History*, supplement no. 11, London 1991 (http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=8639815), pp.29-40.

[37] Landers, *Death and the metropolis*, p.70.

Timber for the supplying the South side of the Citty with water as it for almost this hundred yeares'[38]

In 1606 another attempt was made to provide an alternative source of water supply to the city through the passing of 'An Act for the bringing in of a fresh Stream of running Water to the North Parts of the City of London.'[39] The preamble to the Act stated that 'it is found very convenient and necessary to have a fresh stream of running Water…from the Springs of Chadwell and Amwell, and other Springs in the County of Hertford.'[40] The Act gave the City delegated powers in terms of laying out 'such convenient Limits of ground for making of the Trench' and to 'make satisfaction or Composition [compensation] to and with the Lords, Owners and Occupiers of the…Grounds through which the New Cut or River shall be made….'[41] The main projector of this great work of engineering was Hugh Myddleton, a rich City Goldsmith who persuaded James I to provide financial backing for it and in 1619 to incorporate it by royal charter as the New River Company.[42] The New River built by Myddleton comprised an open channel, constructed in accordance with requirements of the 1606 Act 'at the breadth of ten Foot and not above'[43] and was four feet deep and no less than thirty-eight miles in length, along which spring water from Hertfordshire flowed into a reservoir in Islington.

The New River certainly enlarged London's water supply following its construction between 1608 and 1613 and was to become the principal source of piped water in the latter part of this study period.[44] Initially, however, the number of customers was small and Gough has commented that there was no eagerness on the part of consumers to take 'Myddleton water',[45] for Stow has informed us that the old

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[38] Section IX of 'An Act for rebuilding the Citty of London.' pp. 603-612.

[39] 3 James I, c.18, quoted Gough, *Myddleton,* p.33.

[40] Ibid.

[41] Ibid.

[42] Gough, *Myddleton,* p.33.

[43] Ibid. p.31

[44] Landers, *Death and the metropolis,* p.70. Gough suggests that the demand increased significantly in the 1630s, Gough, *Sir Hugh Myddleton,* p.81.

[45] Gough, *Myddleton, p.33.*

conduits supplied water free of charge. After 'an initial spurt from a small beginning, the number of tenants increased very slowly. At mid-summer 1614 there were 37 of them; this figure had risen to 175 by Michaelmas, and 351 by Christmas, but at Lady Day 1615 it was only 384, and it was not until Michaelmas 1618 that the number of tenants exceeded 1,000.'[46]

There is much modern epidemiological evidence that suggests different modes of water supply can produce wide-ranging fluctuations in enteric diseases within a relatively small area. The mapping of enteric disease pertaining to water supplies relates to the social epidemiology investigation in Chapter 7 and to place this into context some consideration of water quality is required.

4.2.ii Water quality

The supply of water has traditionally been considered an aspect of town planning [47] but its purification is a late nineteenth- and early twentieth-century development.[48] Despite the abundance of Thames water, we have seen how supplies were brought into the city centre in conduits and the New River. Weinstein considers that the quality of water in the early modern London was barely an improvement on that of the medieval city; the Thames had a dual purpose as a water supply and sewer. [49] The poor quality of the Thames water may be a significant factor in the high mortality in

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[46] Ibid. 66.

[47] Borsay, *The English Urban Renaissance,* pp. 18,70, 224.

[48] In the year 1804, the first large municipal water treatment plant was installed in Paisley in Scotland in order to provide treated water to every resident. This revolutionary installation prompted the idea that all people should have access to clean drinking water. However, it would be some time before this ambitious idea would be implemented widely throughout the world see M.N Baker, and Abel Wolman, *The Quest for Pure Water: A History of the Twentieth Century, Volume 1 and 2* (Lancaster Press, USA, 1984), p.78

[49] Weinstein, 'New urban demands', p.34.

the riverside parishes.[50] Similar problems existed in contemporary Paris, with the polluted Seine, belying the adage that it had 'sprung from an angel's thigh'.[51] Typically, the quality of public wells, such as Holywell, was described as "much decayed and marred with filthiness."[52] Chapter 6 will consider contamination of private wells. With regard to the conduits, if the underground pipes serving them were broken through lack of maintenance or by illegal connections, this could cause contamination. Schofield has described how the management of the public conduits included a Warden or Marshall, often a neighbour of the conduit, who was in charge of its upkeep. Schofield considers that tapping into the public water supply was a rare occurrence, and was usually stopped by the City authorities when they found out.[53] Consideration must be given to the possibility, however, that many other cases were undiscovered.

Before the Fire the City had difficulties repairing broken underground pipes because their exact route was not known. Although there seems to be no evidence that the Viewers acted to ensure water supplies, it would appear that the City made use of the delegated powers to use the services of the Surveyors appointed under the Rebuilding Act of 1667. On 22 June 1669 the Court of Aldermen decided that all pipes and aqueducts should be shown on a map and that Robert Hooke was to organise the survey. The idea was far-sighted but Hooke was not given enough resources to produce such a map before reconstruction of the buildings took place.[54] Thus, problems of underground pipes were dealt with piecemeal and as late as 1682 the City was still calling on its Surveyors to take views of water supplies. It was not just ageing pipes that were a problem; new building works were causing damage. Hooke and Oliver were asked to view the water supply 'which formerly came very forcibly to the conduit [in Cheapside] doth not now come so forcifully as formerly

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[50] R. Finlay, Population and the Metropolis, *The Demography of London 1580-1650* (Cambridge 1981), p.103.

[51] Brockliss and Jones, *The Medical World of Early Modern France* p.780.

[52] Weinstein, 'New urban demands' p.34; see also the account of a polluted well given by Forbes in his *Chronicle from Aldgate*, p.150.

[53] Schofield, *The Building of London*, p.79.

[54] Cooper, *Robert Hooke*, p.183.

but that a great part thereof is lost or diverted.' [55] They noted that labourers 'who are digging for bricks' had damaged the pipes and the 'water is diverted and quite lost.' There was also the excavation of 'severall new vaults that have been made under the Street either very near or under the main pipes that convey this [supply] from houses into Cheapside.'[56] This certificate does not describe any remedial action.

It would appear that the early modern expectation was that the best water came from rainwater or from fountains or springs, and flowed swiftly.[57] Modern studies have revealed the level of contamination that can take place in water supplies. Rainwater will be contaminated by suspended impurities as it falls through the air. These impurities are principally carbon dioxide, sulphur and nitrous oxides originating from domestic flues and industrial manufacturing processes. The mixture of these impurities and rainfall produce 'acid rain' an occurrence frequently attributed with the destruction of the fabric of buildings and plant life.[58] In 1661 John Evelyn referred to 'a Cloud of Sulphure' above London that was produced by the burning of 'Sea-coal'[59] which brought about the corrosion of the 'Iron-bars and hardest stones'[60] to buildings and caused the death of '*Bees* and *Flowers* abroad, suffering nothing in our Gardens to bud, display themselves, or ripen…'[61]

A more direct source of contamination relates to surface and substrata water, that is rivers, wells and springs. Contamination can occur through a variety of sources, not just from the actions of humans but also through organic matter from decaying vegetation and animals. These are normally associated with ammonia compounds in the water or bacteria. Certain types of bacteria present in water can be responsible for outbreaks of typhoid, cholera and dysentery.[62] Although municipal

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[55] LMA COL/SJ/27/470 93.52 Feb 27 1682.

[56] Ibid.

[57] Wear, 'Health and the environment' p. 143.

[58] Fred Hall and Roger Greeno, *Building Services* (Elsevier, 2007), p.3

[59] Evelyn, *Fumifugium*, p.9.

[60] Ibid. p.20.

[61] Ibid.

[62] Hall and Greeno, *Building Services*, p.3.

treatment of water was not developed in this study period, methods of detecting contaminated water were pursued. In 1617 William Vaughan suggested that the quality of water could be assessed by 'putting a clean Napkin in it and if any spots appeare upon the same they suspect the goodness of the water.'[63] In 1627 Sir Robert Bacon began experimenting with a form of sand filtration. His experiments proved largely unsuccessful, but his work sparked a movement of water treatment experimentation.[64]

In 1675 the self-educated Dutch naturalist, Antony van Leeuwenhoek wrote to the Royal Society in London that he had 'discover'd living creatures in Rain water, which had stood but a few days in a new earthen pot…'[65] He had produced a microscope that allowed scientists to view a whole new world of drinking water contamination. With his invention, Leeuwenhoek became the first person to discover micro-organisms in water in 1676.[66]

Modern studies have estimated that untreated river water can contain as much as 41,000 microbes per litre caused by the organic pollutants described above [67] and this must therefore call into question the assumption that the outer suburbs of early modern London had relatively good quality water supplies. Although the early modern writers did not have the apparatus to measure the extent of contamination, Venner did observe in 1628 that river water could be 'polluted by the mixture of other things, as it commeth to passe in Rivers, that run thorow marish places, or neere unto populous Townes and Cities: for then, by reason of all manner of filth running, or cast into them, they become corrupt and unwholesome.'[68]

These observations and guidance given by Vaughan and Venner were in the context of 'self-help.' Venner stated that it was up to the inhabitants of towns to find and to select wholesome river water which 'runneth with a full streame upon gravel,

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[63] William Vaughan, *Directions of Health* (London, 1617), pp. 25-6, in Wear 'Health and the environment' p.143.

[64] Baker and Wolman, *The Quest*, p.61

[65] Quoted in Baker, and Wolman, *The Quest*, p.391.

[66] Ibid.

[67] Hall and Greeno, *Building Services*, p.3.

[68] Venner, *Via Recta ad Vitam Longam*, p.10, quoted in Wear 'Health and the environment' p.143.

Pebble-stones, Rockes, or pure earth: for that water, by reason of the purity of the place, motion, and radiant splendor of the Sun is thinner, sweeter and therefore more pure and wholesome.'[69] The study of London's New River does suggest, however, that early modern environmental law did at least consider some aspects of providing clean water to the city.

Although Myddleton was eventually selected as the projector for the New River, he was initially in competition with other potential builders and engineers, including William Inglebert, who proposed a more expensive but environmentally sustainable scheme. He suggested that 'for the sweete keeping thereof ' and to lessen damage to the ground, the water should be 'brought and conveyed in and through a trunk or vault of brick or stone inclosed, and in some places where need is, raised upon arches', instead of in an open trench or sewer.'[70] The expense of this scheme was the likely reason for the construction of the open channel system built by Myddleton.

This supply from spring water may have evoked a perception of clear clean water from the countryside but the scheme still had its critics, mainly in terms of the costs and damage to the land and rivers through which it was to pass. In response to the detractors of scheme, Myddleton and his supporters stressed significant health benefits to the public at large as well as to the individual consumers of the water. In terms of public health, Myddleton *et al* stated that at night surplus water would 'runne into the towne ditches and so to the tower ditche and at the pleasure to the fleete ditch and common sewers', while 'in extremitie of heate' it would be possible 'to lette runne the cocks to coole the streets and clenze the kennels, wherby to avoide all ill aires and infeccons.'[71]

With regard to individual consumers, the advantages were expressed in terms of getting water '25 foote high in any house in London or within the liberties or suburbes', so that 'pore people' would no longer be 'inforced to use foule and

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[69] Ibid.

[70] Gough, *Myddleton*, p.32

[71] Ibid., p.44.

unwholesome water which breedeth great infections.'[72] These are significant statements outlining the early modern understanding of the connection between poor quality water and disease. Opponents of the completed scheme suggest that Myddleton's claims failed on three counts: water pressure was not high enough to supply water above one storey; the poor could not afford the supply, for a 'fine' or premium was charged when the water supply was first laid on, and a quarterly rent of 5s. or 6s. 8d;[73] and quality was poor, with allegations of 'the foulnesse and muddinesse of it (coming in an open trench).'[74]

In a modern water supply system, river water flows into an impounding reservoir. The untreated and unfiltered water in such a reservoir may have a 'residence time' of several months and during that time normal biological processes can reduce the contaminants down to 1,500 microbes per litre.[75] Myddleton's New River was designed to flow into an early modern equivalent of an impounding reservoir north of the city. Consideration must therefore be given to the possibility that the microbe count in Myddleton's New River would have been reduced along the lines of modern estimates, from 41,000 down to 1,500 per litre. Other things being equal, it would appear that this very much depends upon the length of time the water was permitted to reside in the reservoir.

Gough describes the reservoir or 'the New River Head' as an existing pond in Clerkenwell, 'commonly called the Ducking pond.'[76] This became the Round Pond, and was wharfed in 1613 with oak boards, of which 4,800 were needed, at a cost of 7s. 6d. a hundred. It was surrounded by a brick wall, built by a Stephen Boone, whose name appears regularly in the New River accounts as a contractor for brick bridges, and who also (at a cost of £102.17s) built the chimneys and other brickwork in the Water House.[77] This was erected on the south side of the Round Pond and in the

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[72] Ibid.,p.44.

[73] Ibid., p.66.

[74] Ibid., p.66.

[75] Hall and Greeno, *Building Services*, p.3.

[76] Gough, *Myddleton*, p. 59.

[77] Ibid., The accounts are dated 4 December 1613.

absence of details regarding the size of the reservoir, the Water House provides some indication of scale in the portrait of Sir John Backhouse in the National Gallery, London.[78] Compared to the modern impounding reservoirs, the Round Pound appears relatively small in size. Although the former are likely to serve a much larger modern population, it is possible that the critical 'residence time' of water in the Round Pond was compromised due to its relatively small size and the demands of an increasing number of consumers into the 1630s.

The next stage in the purification of the water supply in the modern era is to transport it from the impounding reservoir through primary and secondary filters where the microbe count per litre would be reduced from 500 to 50 respectively. The process of chlorination then eliminates the microbe count completely before it is relayed to a service reservoir and the distribution mains.[79] These latter stages in water supply in the modern era were absent during this study period. Instead, wooden pipes set below ground level conveyed water from the Round Pond across the fields to the city centre along two routes: one to St John Street and the other to Goswell and Aldersgate Streets. Small lead pipes were then to branch off to those houses whose occupiers wished to pay for the supply.

Thus, the provision of supplies to certain areas and members of the population would appear to have been the full extent of local government obligation, for there was no requirement under the custom of the City to provide a safe, adequate, potable and palatable water supply to each dwelling under pressure; nor was there any requirement for safe storage. The storage of rainwater in tanks and cisterns comes under the subject of 'building services' and is therefore considered in Chapter 6. There is evidence, however, of early modern environmental law attempting to protect the supply from the New River before it reached the front door of dwellings. On 19 June 1615 the Privy Council referred to: 'many abuses and misdemeanors daylie committed and done, in and upon the said river, by lewed and ill-disposed people […] casting in dogges and filth, and letting in sewers and other fowle and uncleane

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[78] Ibid., p.59. A copy of the portrait is shown in Gough.

[79] Ibid.

water…'[80] The New River was regularly patrolled by the 'walksmen', but obviously they could not police the whole river at any one time. Nevertheless, offenders who were discovered were brought before the Council 'to answeare to their misdemeanors'[81]

It is clear that from the above analysis that the quality of various water supplies into early modern London must be considered in relative rather than absolute terms. Modern studies have revealed that even where there are unfiltered and un-chlorinated supplies, levels of enteric disease are affected by the mode of supply within dwellings. Chapter 6 will consider the various water supply, storage and consumption to different houses.

4.2.iii The collection and disposal of excreta and waste water

As there was no main drainage in the city centre during the study period, dwellings often used cess-pits to collect foul water from privies. Acccording to Earnest Sabine the cess-pit system came into common use in the late medieval period partly because of the evergrowing public opinion against the discharge of 'privy filth' into streams, ditches and open sewers of a city growing ever more populated: 'The restrictions imposed in the fourteenth and fifteeenth centuries were maintained and even strengthened.'[82] The Statute of the Streets,1633, stated that 'no man was to make 'widrawes' in any town ditches or town gullets under a penalty of 20s; and in accordance with an Act of the Common Council of 1671, no man was to 'make or continue any withdraughts, Seat or Seats for Houses of Easements over, or Dreins into any common sewers without licence of the commisioners for the time being, under penalty of 40s. a month.'[83] The mention of a licence suggests that people of wealth and influence could, in certain instances, purchase the right to discharge the contents of their cess-pit into the city's sewers. The severe penalties attached to so doing without a licence may have provided a significant deterrent, as long as it was

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[80] *Acts of Privy Council, 1615-16,* pp.212-13, quoted in Gough, *Sir Hugh Myddleton,* p. 67.

[81] Ibid.

[82] Ernest Sabine, 'Latrines and cesspools of Medieval London' in *Speculum* (Medieval Academy of America, 1934), p.318.

[83] Ibid.

enforced by the City. These requirements of environmental law, along with public opinion, must have driven the owners and occupiers of buildings to construct more cesspits; consideration is now given to the control over their construction.

By modern definition, a cesspit is simply a holding tank, which retains the sewerage until it is collected by occupiers or contractors for disposal elsewhere.[84] There are a large number of Viewers' certificates in the early part of the study period specifying sizes of new cesspits as well as alterations to accommodate additional dwellings.[85] It is precisely this development and redevelopment of London by landlords maximizing occupation of their properties without investing in sanitation that led to a notable Common Council Order in 1570. The Order called for urgent action in ancient alleys 'that […] have only a common house of easement for the whole alley.'[86] In consideration of houses that had been subdivided there is evidence of Custom being used to force the developer to provide 'sufficient […] houses of office.[87] It would appear that these applied to individual cases but would not have been used to set a precedent.

The vault in the basement or the cesspit in the back yard was to be emptied by the night-soil men, but it seems their visits were irregular. There were, however, some attempts to control the time and process of emptying. In 1671 an Act of the Common Council stated that 'no goung-fermer' should carry ordure till after ten o'clock in winter and eleven o'clock in summer at night; the Act also imposed a penalty of 13s. 4d. against anyone convicted of spilling filth into the streets.[88] Sabine is of the opinion that there is every reason to believe that the general practice of night cleaning was established long before the passing of the City's act.[89]

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[84] Marshal and Worthing, *The Construction of Houses*, (The Estates Gazette, 1995), p.290

[85] For example, *London Viewers* 267 [C.62] Feb. 3 1550.

[86] Cited in Harding, 'Housing and Health, p.36.

[87] Ibid.

[88] Sabine, 'Latrines and cesspools', p.317.

[89] Ibid.

The medieval *Assize* of Building did, however, stipulate that cess-pits must be a minimum distance from the boundary between dwellings.[90] The distances varied depending upon whether the pit was lined in with stone, in which case it could be within two and a half feet of the boundary, or if it was a simple earth pit it had to be three feet and a half from the boundary (figure 4.01). The distances were therefore specified through Custom in the context of possible leakages. A similar provision was included in the building codes of contemporary Paris.[91] Sabine has observed very few cases in the medieval period were brought before the Court for non-compliance;[92] perhaps this reflects the lower density of building in the city centre during this earlier period. There is little evidence that these distances were enforced within early modern London, however, with the Viewers possibly recognising the impracticalities of achieving this as yards and gardens were infilled with additional buildings. For example, in specifying the position of a new 'jakes' to a property in Friday Street, the Viewers were focusing more on its construction than its position relative to boundaries.[93] This became a typical approach. Mood concludes that basic to the prevention of enteric disease and morbidity from diarrhoeal disease is the provision in all dwellings of a safe, sanitary means for the disposal of human excreta.[94] The function and perfomance of privies, constructed according to building practice rather than through the requirments of environmental law, is considered in Chapter 6.

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[90] K.G. Whittick, *The Party Wall: A History* (Faculty of Party Wall Surveyors, 2007), p.16.

[91] Orest Ranum, *Paris in the Age of Absolutism*, p.103.

[92] Sabine, 'Latrines and cesspools' p.319.

[93] London Viewers, 296 [C.91] April 14 1551.

[94] Mood, 'Fundamentals of healthful housing' p.310.

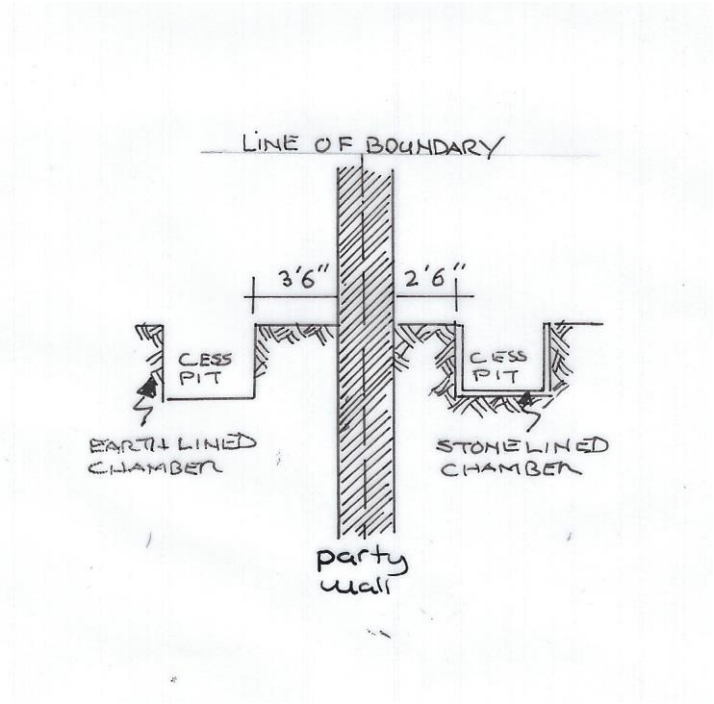

Figure 4.01. A sectional sketch showing Medieval building regulation requirements for the construction and position of cess-pits relative to neighbouring properties, adapted from Whittick, *The Party Wall*, p.16.

As noted earlier, the collection and storage of rainwater for drinking was not pursued through building policies; Custom and statutes focused more on its potential damage to property and health at source. Much of the water carried via the street gutters and channels, known as kennels, originated on the roofs. Other liquids issued from the interiors of domestic dwellings and business premises.[95] The combined effects of waste water issuing from each house on a street presented a considerable challenge to drainage within the city centre, especially during inclement weather. On wider roads there could be two kennels, each flanking the carriageway. On narrow streets around the city centre, one kennel was more common, running down the middle of the street. The kennels were frequently blocked by waste and excrement.[96]

The intention was for the kennels to flow or trickle into ditches and streams, which in turn discharged into faster-flowing watercourses. A 1550 Viewers' certificate describes a six-foot wide ditch in the grounds of a house in the parish of St. Botolph without Bishopsgate, discharging into 'a common sewer' which 'has been

[95] Cockayne, *Hubbub*, p.196.

[96] Ibid., p.197.

used of old custom.'[97] Thus, the collection and disposal of waste water at ground level was dealt with by Custom and there is some limited evidence that the Viewers were attempting to remove the frequent 'nuisance' of spouting gutters by specifying the use of down-pipes.[98] This evolving Custom was to be incorporated into the statutory requirements of Rebuilding Act of 1667, where 'Water falling as well from the topps of the said Houses as from the said Belconies and Penthouses be conveyed into the Channells by Party pipes on the sides or fronts of the said Houses…'[99]

Section XVIII of the Rebuilding Act made provision for: 'makeing of any new Vaults Drains and Sewers, or to cutt into any Draine or Sewer already made, and for the altering inlargeing amending cleansing and scouring of any old Vaults Sinks or Coo[m]mon Sewers…'[100] Reddaway considers this provision 'must have played its part in improving the health and well-being of her [the city's] inhabitants.'[101] Through the utilisation of the rubble, the levels of the streets were altered to allow stagnant surface water to be drained away.[102] The Rebuilding Act was the instrument that enabled the City to set up the Commissioners for Sewers, including their Surveyors.[103] At the local level, the City wards and parishes continued to manage watercourses and drainage gullies for the physical health of its parishioners through the work of the Viewers; Cooper considers the work of the Surveyors in the post-Fire period was akin to modern public health engineering.[104] The removal of stagnant and possibly polluted water from the streets adjacent to housing must have been conducive to healthful housing but was only part of the problem.

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[97] *London Viewers* [C.63] 18 February 1550.

[98] Ibid., [C.96] 26 May 1551.

[99] Section XI of 'An Act for rebuilding the Citty of London' (1819), pp. 603-612.

[100] Ibid.

[101] Reddaway, *The Rebuilding of London*, p.296.

[102] Ibid. See also Schofield, *Medieval London Houses*, p.6; Section XVIII of the Rebuilding Act 1667.

[103] Ibid.

[104] Cooper, *Robert Hooke*, p.180.

4.2.iv The collection, storage and disposal of refuse and other solid wastes

Probably the most continuous day-to-day concern for citizens of London and Westminster, representing the most immediate threat to health and hygiene, was the collection and removal of refuse.[105] Archaeological reports indicate that in Roman and medieval London pits were dug for refuse.[106] As the density of building in the city centre increased, such refuse pits were no longer feasible.

According to Weinstein, up until 1654 the City employed some 400 ward-appointed scavengers and rakers. Rather than devolving environmental care to local areas, Weinstein views this as the centralisation of a service where Scavengers were charged to see that the people cleaned in front of their house and the City's Viewers insisted that the occupiers of houses maintained the 'commodity in the street down to the kennel.'[107] The direct employment of the scavengers by the City did not appear to be cost effective. A report to the City sought justification in privatising the collection of refuse and waste: 'notwithstanding many persons and considerable sums of money are employed for cleansing streets yet they grow more offensive with dust and unwholesome stenches in summer and in wet weather with dirt, which occasions swarm of Coaches…' [108] When the refuse was collected, the complaint was that it only represented a small quantity of the overall waste and was deposited 'to the common Laystalls, which being so near the City yield great and contagious stench…'[109] The privatised version of refuse and solid waste collection and disposal did not produce tangible improvements.[110]

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[105] Weinstein, 'New urban demands' p.31.

[106] MoL GHT00 Blossom's Inn, 20 - 30 Gresham Street, 20 – 23 Lawrence Lane, 3 – 6 Trump Street, 1- 10 Milk Street & Mumford Court EC1; NGT00 Paternoster Square, Area 4 and Paternoster Row EC4; BDE00 Bow Bells House, Bread Street EC4; LOD00 10-15 Lombard Street EC3.

[107] Act of Parliament in 1662 confirmed by others in 1670, 1690 and 1697, see Weinstein, 'New urban demands' p.34; London Viewers [C.156] 2 October 1555.

[108] CLRO, Misc. MSS 11.25, Proposals of John Layton for a Contract (1654) cited in Weinstein, 'New urban demands' p.31.

[109] Ibid.

[110] Ibid.

Section XIX of the Rebuilding Act gave the City powers to 'prohibit such Trades and Occupations as they shall judge noisome… in the high or principall Streets of the said Citty.'[111] Viewers continued to deal with day-to-day issues regarding laystalls including a particular case in Fenchurch Street that they referred to as a 'dunghill' produced by the use of a building used as a livery stable. The Viewers stated that this 'will be of great annoyance to the neighbourhood…'[112] Hooke and Oliver were instructed by the City to find and stake out sites for laystalls. Little evidence of their success is provided in the City archives although an agreement was reached on the location of slaughter houses with the Master and Wardens of the Company of Butchers.[113] About this time the Commissioners also attempted to use the pre-Fire private contract system, but largely owing to a lack of co-operation by the inhabitants, it proved unworkable.[114]

The apparent failures of building policies in sanitary collection, storage and disposal of refuse and other solid wastes bring into focus the interaction of the external and internal environments which is likely to have contributed to the propagation of various insects, rodents, vermin and animals within buildings. This would not have been a problem peculiar to London for other early modern towns would have experienced similar issues. It is the size of the capital relative to other towns that requires this point to be raised as a significant factor in contributing to enteric diseases.

Refuse brings with it a significant agent in the spread of pathogens; the common housefly, *Musca domestica*. Waller suggests that flies would have travelled from human faeces to food [115] and Michael Howard has noted that the common housefly, has been shown to have been responsible for the transmission of human diseases during epidemics.[116] This species will carry large numbers of disease-

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[111] 'An Act for rebuilding the Citty of London', pp. 603-612.

[112] LMA COL/SJ/27/471. Vol. II.78. Oct. 5 1677

[113] Cooper, *Robert Hooke*, p.183.

[114] Weinstein, 'New urban demands' p.31.

[115] Waller, *1700*, p.98.

[116] Michael Howard, 'The effects on human health of pest infestation in houses', in Burridge and Ormandy (eds.), *Unhealthy Housing*, pp.269-70. Michael Howard is a Senior Environmental Health

causing organisms in its own faeces. It feeds and lays eggs in all kinds of waste and decaying material, including animal and human faeces, and is highly mobile. This mobility enables it to seek out human food readily and its potential for disease transmission is considerable. It may transmit pathogenic organisms mechanically on its body or from its gut when regurgitating food during feeding. The control of houseflies involves good refuse storage and disposal, good hygiene and protecting food from flies during storage and preparation.[117] The failure to control refuse would have contributed significantly to the spread of pathogens. The protection of food during storage and preparation is an important part of housing.

4.3 Population growth and the spread of airborne infections

As noted in Chapter 1, airborne infections, caused by a variety of micro-organisms, include many common diseases affecting humans. The mechanisms of transmissions of the infectious agents may be by droplet nuclei that harbour micro-organisms, as well as by direct contact. Modern studies have placed tuberculosis, pneumonia and meningococcal meningitis into this category whereas plague is described as early modern London's 'most famous killer'.[118] The plague was referred to as a specific concern in the building proclamations. For the reasons described in Chapter 1, plague has not been included the category of *Chronical* Diseases. Small Pox and measles were apparently present in early modern London, spread by the mechanisms described above and killed significant numbers in most years, with regular peaks, suggesting they were both endemic and epidemic. Various forms of fevers were also significant non-plague killers.[119]

Airborne infections are often associated with overcrowding and poor ventilation of dwelling spaces[120] but consideration must be given to how this can be assessed. John Kellet considers that '*population density* is probably the closest one

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Officer specializing in health and safety. He was formerly a lecturer in environmental health at the University of Salford.

[117] Ibid.

[118] Harding, 'Housing and Health', p.31.

[119] Ibid.

[120] Mood, 'Fundamentals of Healthful Housing' p.311 and Kellet 'Crowding and mortality' p.209.

can come to measure the frequency of life events for large groups of the population.'[121] In modern studies, population density is measured in one of three ways; firstly, is population per hectare, described as 'density'; secondly, persons per room, described as 'crowding'; and finally 'population potential'.[122] Only the first two are considered in this study, reflecting as they do, an environmental influence.[123]

4.3.i Population density and physical restrictions in urban areas

Kellet notes that population per acre/hectare studies may underestimate density if, for example, a large part of a city was occupied by industry, and the population was accommodated in one relatively small area. The natural physical limitations of the terrain may also play a significant role. In the context of early modern London, this would apply to Southwark. During the late sixteenth century and the seventeenth century there was enormous unregulated growth in this substantial settlement. In 1678 Southwark had a population of about 30,000 in its four core parishes, making it, if separated from London, England's second largest city; as Defoe put it, 'A royal city were not London by.'[124] Perhaps it was 'royal' in terms of size but not housing quality. The marshy terrain that lay south of the river largely determined Southwark's development pattern. This physical limitation to Southwark's growth forced great density of habitation. The huge population increase could not be accommodated on marshland, so growth was squeezed onto a proliferation of short alleys off existing roads in the late fifteenth century and the early sixteenth century.[125]

Although unregulated growth may produce problems in 'population density', planning policies may also inadvertently contribute to overcrowding. In the context of early modern London, a significant town planning policy in the form of a royal

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[121] Ibid.

[122] Ibid.

[123] The Oxford Dictionary of Geography defines *Population Potential* as 'the accessibility of people from a given point; that is, a measurement of how near people are to a point. The population potential at one place is the sum of the ratios of population at all other points to the distances from the place in question to those points.'

[124] Defoe, *A Tour*, p.178.

[125] Guillery, *Small House*, p.118.

proclamation was 'Given at Nonesuch' on the 7th June 1580.[126] The preamble to the proclamation suggested that local and national government were as one in forbidding new building, for Queen Elizabeth was acting 'on the advice of her 'Counsell' and being 'moved by the considerate opinions of the Lord Mayor, Alderman and other grave wise men in or about the Citie'[127] Significantly, this proclamation relates population density to health, not only at city level but nationally:

> If any plague or popular sickness shoulde by Gods permission, enter amongst those multitudes, that the same would not only spread it selfe and invade the whole citie and confines, as great mortalitie should ensue to the same, where her Majesties personall presence is many times required, besides the great confluence of people from all other parts of the Realme, by reason of the ordinary terms of justice there holden, the infection would be also dispersed through all other parts of the Realme to the manifest danger of the whole body thereof.[128]

This proclamation formed the basis of a further seventeen edicts and statutes over a ninety-year period and historians and writers have different views with regard to its impact on the environment and health. As noted in the opening Chapter, George has observed that its aims were carried on by the Stuarts and Cromwell and were 'misguided.'[129] George also considered that the prohibition of building encouraged the erection of substandard buildings in yards and backstreets, leading to high population density.[130] The 1580 proclamation did 'charge and strictly command all manner of persons, of what qualitie soever they be, to desist and forbeare from any new buildings of any house or tenement within three miles from any of the gates of the said citie of London…'[131] Rasmussen draws our attention to the views of the eminent twentieth-century town planner, Werner Hegemann. The latter considered that the 1580 proclamation was a very far-seeing town planning policy, and could be seen as an attempt to create a broad agricultural belt around London and at the same

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[126] *Calendar of State Papers, Elizabeth, Volume 14: 1579-1580* (1904), pp. 284-302.

[127] Ibid.

[128] Ibid.

[129] George, *London Life*, p. 82.

[130] Ibid.

[131] *Calendar of State Papers, Elizabeth, Volume 14: 1579-1580* (1904), pp. 284-302.

time as an encouragement for developing new quarters outside this open space.[132] Rasmussen observes that 'read in this way the proclamation would certainly be in advance of its age, anticipating the garden city ideas of late years. But it proves impossible to uphold his interpretation.'[133] Rasmussen explains that different parts of the proclamation show quite different aims and he refers to this edict as 'but a single link in a chain of laws which tried to remedy the numerous evils caused by economic change.'[134]

Although Hegemann's interpretation of the proclamation is impossible to sustain it touches upon the modern town planning concept of 'zoning', that is, designating specific areas of a town for particular land use. In 1661 Evelyn proposed a form of town planning with a green belt comprising a mass of sweet smelling trees, bushes, and plants to be planted around London to counteract pollution.[135] Evelyn also suggested that the industries and trades polluting London's air be relocated, 'I affirm they might all be remov'd to some distant places.'[136] Schofield notes that tanning was already expelled from the city centre in an earlier period[137] but it would appear that noxious work processes within housing were prohibited by city centre landlords rather than by statute or environmental law. This was based on the desire of the landlords to maintain the quality of their properties to uphold rents.[138] Power suggests that economic factors defined 'zoning' within the city centre rather than local byelaws; occupations gravitated towards their markets and as a result Power has shown how commercial interest dictated where occupation groups lived and worked.[139] It could be argued that such factors, as discussed in Chapter 7, had a

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[132] Werner Hegemann, *Der Städtebau nach den Ergebnissen der Allgemeinen Städtebau-Ausstellung*, in Rasmussen, *The Unique City*, p.64.

[133] Ibid.

[134] Ibid., p.65.

[135] Evelyn, *Fumifugium*, p.30.

[136] Ibid.

[137] Unfortunately a date is not given in Schofield, *Medieval London Houses*, p.87.

[138] Harding, 'Housing and Health', p.26.

[139] Power 'The Social Topography', p.212.

prominent role in the use of London's land and buildings and with it a possible influence on the quality of the built environment.

The commitment of the City to enforcing the prohibition of new building was called into question in a letter from the Privy Council in 1583. The Council considered that the provisions invested in the City through the Queen's proclamation were 'ineffectually carried out… to the danger of pestilence and riot.'[140] The response from the City was swift, stating that:

> …the Court of Aldermen had taken steps to ascertain the number of houses erected contrary to the Proclamation that they understood from his Lordship, they were not to include any erected in the late dissolved monasteries and such other places, pretending exemption from the City's liberties, but that the same should rather be done by the Justices, of Middlesex, as parcel of that county…[141]

The City's role in the drafting of the prohibition of building in 1580 may also have been due to its fear of suburban competition. It had no wish to annex the turbulent and ever growing suburbs. What the Court of Aldermen wanted, purely for the protection of the City's own interests, was a measure of supervisory authority over the out-parishes, but unaccompanied by the basic responsibility for the relief of the poor or the maintenance of law and order there. They were also fearful that the creation of the boisterous suburbs of several fully fledged wards would upset the time-honoured machinery of the City's existing civic polity.[142]

If the City was not prepared to commit resources to the suburbs, consideration must be given to those buildings included in their list to the Privy Council. The Viewers' oath, which was apparently framed in the Elizabethan period, may provide some clues. The oath required the Viewers not to '… make or suffer […] any newe

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[140] 'Buildings', *Analytical index to the series of records known as the Remembrancia: 1579-1664* (1878), pp. 41-51, Letter I.495, 8 April 1585. URL: http://www.british-history.ac.uk/report.aspx?compid=59908&strquery=Proclamation 1602 City London Date accessed: 07 December 2009

[141] Ibid. Letter I.496, dated April 1583

[142] See Brett-James, *Stuart London*, Chapter IX and Sheppard, *London: A History*, pp.190-1.

building within the liberty of this Citty…'[143] This pledge to enforce prohibition did, however, allow a certain degree of latitude towards an unauthorised building. Such buildings would escape demolition if it could be demonstrated to the 'Maior and Aldermen or Chamberleyne for the time being to th'entent that reformation thereof may be had…'[144] The inclusion of this pragmatic provision would suggest that the oath pre-dates the proclamation of 1580. There does not appear to be a single case where the Viewers have initiated demolition of an unauthorised substantially built house. The only structures they certified to be 'withdrawn' were sheds to accommodate the poor. Even allowing for the loss of certificates from the City records, this is striking and may be due to a combination of conflicting aims in the edicts and statutes.

Rasmussen concludes that 'It was of course a hopeless task to try and stop the growth of the City and we must stop trying to see any social benefit in that. What saves the town is first of all an aversion of the citizens against overcrowding and their conservative clinging to the medieval form of housing.'[145] He considers that there was some irony in London's development. The failure in prohibiting new buildings allowed London to expand into a 'scattered' form; this he considered was healthier than congested contemporary cities on mainland Europe, such as Paris: 'if all houses were surrounded by sufficient open space housing details [as pursued by building regulations] would be of less importance hygienically.'[146] According to Rasmussen a laissez-faire form of town planning produced a relatively low density and healthful city and obviated the need for building regulations controlling the quality of buildings. Barnes also considers that town planning should have taken priority over building regulations but he differs from Rasmussen, in that he feels a stricter form of 'planning control' should have been pursued.[147]

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[143] Jupp and Pocock, *An Historical Account of the Worshipful Company of Carpenters* p.193. Unfortunately the date of the oath is not given and cannot be found in the City records, despite the commendable efforts of the archivists at the London Metropolitan Archives.

[144] Ibid.

[145] Rasmussen, *The Unique City*, p.67.

[146] Ibid. p.105.

[147] Barnes,'The Prerogative' p.1349.

Barnes has argued that environmental law pertaining to prohibition was evolving up to the on-set of civil war.[148] The counter-argument is that there is little subject matter to evolve in the substantive nature of prohibition. There was only one significant variation in a substantive context in a further seventeen building proclamations issued over a ninety-year period; this was the size of the area under their jurisdiction. The three-mile area of prohibition of 1580 was reduced to two miles in 1625[149] and expanded by Cromwell to ten miles in in 1656.[150]

Barnes laments the change in emphasis from the prohibition of building through planning control towards building standards.[151] This appears to be very much the system used in contemporary Paris. Rasmussen considered that the approach to town planning in early modern Europe was based on the acceptance that the congestion of people in the cities was inevitable and therefore the law-makers only tried to remedy the worst evils by building regulations on 'all sorts of technical details.'[152] Hillary Ballon has countered Rasmussen's argument that early modern Paris was constrained by its topography.[153] Ballon does acknowledge that the French authorities accepted that the congestion of a successful commercial city was inevitable but building quality was sought through a combination of creative town planning and building regulations.[154]

Some Viewers' certificates produced in pre-Fire London would suggest that they were continuing to follow the remit of their oath and in doing so a subtle form of creative town planning was evolving. Rather than demolishing all unauthorised

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[148] Ibid. p.1335

[149] The Proclamation of Charles I, 2 May 1625, quoted in Knowles and Pitt, *A History of Building Regulations*, p.21.

[150] 'An Act for the preventing the multiplicity of Buildings in and about the Suburbs of London, and within ten miles of the same', *Acts and Ordinances of the Interregnum, 1642-1660* (1911), pp. 1223-1234. URL: http://www.british-history.ac.uk/report.aspx?compid=56618 Date accessed: 04 February 2012

[151] Barnes,'The Prerogative' p.1349.

[152] Rasmussen, *The Unique City*, p.68.

[153] Hilary Ballon, *The Paris of Henri IV* (MIT Press, 1991), p.254.

[154] Ibid.

buildings, the Viewers were often asked to advise upon technical details not least pertaining to the reduction in density. In 1606 Nicholas Park was ordered to reduce the number of 'several small tenements' in his conversion of an 'ancient brew-house in Southwark' to three.[155] Although the Order stated ' that this should not be drawn into a precedent' there are other examples of the Viewers reporting on the vertical and horizontal subdivision of buildings, despite the 1580 proclamation stating that to avoid multitudes of families being 'heaped' together the 'converting of any one house into a multitude of such tenements' was prohibited.[156] Rather than ordering the conversion of tenements back to a single dwelling, the Viewers generally reported on disputes over ownership of specific parts of the buildings and responsibility for repairs. A number of Treswell's surveys record the sub-division of various tenements with the use of partitions. A survey in 1612 of houses on the north side of Hart Street, later Crutched Friars, described two tenements 'sometymes but one.'[157] In the same year a survey of two-and-a-half storey buildings on the north side of Fleet Lane revealed that a number were clearly in multi-occupation, with some split into one-room tenancies on the ground floor.[158]

Barnes has drawn attention to a pragmatic approach by the building commissioners in the West End where prohibition of new building was being largely ignored. He describes how Inigo Jones, Surveyor to James I, was committed to pursuing the desire of his patron in seeking high standards on technical issues. Jones was the 'technical arbiter' of the successive commissions of building and, after the accession of Charles I in 1625, was also the leading spirit of the commission. He viewed and recommended action on buildings already constructed, in the process of construction or already planned. He was indefatigable in checking plans and designs. Barnes has made his argument for the failure of prohibition from a unilateral perspective, that is, the prohibition of building for all classes. [159] The buildings

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[155] *Remembrancia: 1579-1664* (1878), pp. 41-51. Letter II.263, May 1606

[156] *Calendar of State Papers, Elizabeth, Volume 14: 1579-1580* (1904), pp. 284-302.

[157] Treswell, *London Surveys* p.68.

[158] Ibid. p.79.

[159] Barnes, 'The Prerogative'p.1343.

attended to by Jones, however, were those of good quality, and did not include dwellings built for the poor.

Within the prosperous city centre the requirement for accommodation was in conflict with limited space and therefore the only remedy was to build upwards. City centre parishes were very densely occupied, perhaps as high as 230 persons per acre in the very centre just before the Fire, grading down to 150 per acre or fewer just inside the walls. The inner suburbs had densities of 140-55 per acre. The outer suburban parishes were generally so large and so irregularly settled, with some large spaces remaining unbuilt, that it is difficult to give meaningful numbers.[160] Population density is in any case more complicated than person per acre and has to be considered in the context of occupied floor space rather than the footprint of buildings. [161] This approach is very similar to the concept of 'crowding'.

4.3.ii Crowding and room size

The proclamation of 1580 expressed concern over housing conditions that would be described in the modern era as 'crowding'. The edict considered that the preservation of public health 'may seem impossible to continue' where it was observed that 'such great multitudes of people [are] brought to inhabite in small rooms.'[162] Consideration is now given to how modern 'crowding' studies can assist in relating population per room to the spread of air-borne pathogens in early modern London.

Kellet has noted that population per room studies often fail to take into account the size of the room: 'Victorian terrace houses may register higher crowding than modern purpose built flats, though the space in the former is much greater.'[163] Persons per room also do not take account of the geometrical progression of possible interactions that can occur when the number of the household increases.[164] The 'conduction' of pathogens was discussed in Chapter 2 and this would be intensified in

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[160] Harding, 'Housing and Health, p.33.

[161] Ibid.

[162] *Calendar of State Papers, Elizabeth, Volume 14: 1579-1580* (1904), pp. 284-302.

[163] Kellet,'Crowding and Mortality'p.210.

[164] Ibid.

small overcrowded rooms. However, the study of room size and the interaction of occupants in early modern London are problematic. While some housing for the poor in the city centre and inner suburbs were occasionally surprisingly spacious, most dwellings were small. William Baer has studied the certificates for offending houses and builders and concluded that that the floor area of a one-room shed may have been in the region of 110-160 square feet.[165]

An examination of the floor plans produced by Treswell shows that the city centre comprised houses of differing sizes. London's building policies did not stipulate house dimensions, whereas minimum sizes were at least specified, if not always enforced, in the seventeenth-century building codes of Paris.[166] Nevertheless, Schofield has placed Treswell's surveys into four house types; these are presented in order of increasing size of ground-floor plan. [167] The average size of a room in the smallest 'Type 1' house was 185 square feet.[168] These houses generally had one room per floor. Type 2 houses are more numerous, with two rooms per floor, spread over three or more floors. Although these house are larger there would not appear to be a significant difference in room size, averaging around 190 square feet. The Type 3 house is considered by Schofield to be represented by middle-sized dwelling with several rooms on each floor.[169] The various houses cited by Schofield fit less well into this category, and the numerous rooms are too varied for an 'average' size to be defined. Such problems are compounded with the miscellaneous group of larger properties that make up 'Type 4' houses; these include courtyard houses and inns.

Power has estimated the average size of an east London house to be about 200 square feet on the ground floor. With this house type there could be one or two rooms per floor, thus an average room could vary from 100 to 200 square feet.[170] The houses in the West End were very different and within this suburb there was

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[165] Baer, 'Housing for the Lesser sort' p.66.

[166] Ranum, *Paris in the Age of Absolutism*, pp. 102-3.

[167] *London Surveys of Ralph Treswell*, pp. 11-17.

[168] Ibid. Plate 6.

[169] Ibid. p.159.

[170] Power, 'East London Housing' p.250.

considerable variation.[171] McKellar has observed that most developments for the middling-sort in the West End, for which the details survive, seem to have shied away from having houses of a uniform size.[172] According to Power, the houses of the West End where larger than those in the east.[173]

It is the cubic capacity of the rooms, however, which is essential in this analysis of the possible effects of 'crowding' on health and therefore average room heights are required. Treswell did not provide such information in his surveys and Power has acknowledged a similar dearth of information in his study of East End housing.[174] Keene has offered a method of establishing room heights. He suggests that in the absence of extensive contemporary records, the antecedents of early modern room heights may be traced by studying the equivalent heights specified in the more numerous London building contracts of the fourteenth and fifteenth centuries.[175] It would appear that storey heights were reasonably generous among most house types and were enhanced in the city centre through the Rebuilding Act.[176]

With regard to the increase in geometrical progression of interactions that can occur when the number of the household expands *People in Place* have estimated that household sizes were larger in the city centre averaging 6.6 persons. The household in poorer parishes just outside the gates, such as Aldgate comprised households averaging 4.8 persons. [177] Baer has estimated the average household of the poor occupying sheds was 4.57 persons. With regard to other forms of dwellings for the poor, churchwardens often included in their surveys descriptions of the crowding they encountered when compiling the *Returns of Divided Houses* in 1638.[178]

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[171] Power 'East and West' pp.171-2.

[172] McKellar, *The birth of modern London,* p.130

[173] Power 'East and West' pp.171-2.

[174] Power 'East London housing' p.249.

[175] Keene,'Tall Buildings', p.206.

[176] See sections VII, VIII and IX of 'An Act for rebuilding the Citty of London' pp. 603-612.

[177] Harding *et al*, *People in Place*, p.8.

[178] T.C. Dale (ed.), *Return of Divided Houses in City of London 1637* (1 June 1937), quoted in Baer, 'Housing for the Lesser sort in Stuart London' pp. 70-2.

From these returns Baer has observed that in over 2,000 entries, only 12 descriptions of crowded conditions were recorded. This is striking but according to Baer many wards did not submit returns because they did not consider that crowding was a major problem in their area to justify such an extensive investigation. On the other hand, those returns submitted were volunteered, not asked for, and Baer concludes that they may have represented only the very worst conditions.[179]

In both Cheapside and Aldgate, the average number of children per couple (whether that couple was still represented by both parties or by a lone parent) was similar in size; the difference in household size arose because Cheapside households had more apprentices and servants.[180] The city centre in general had a greater proportion of servants than the suburbs. [181] This would suggest that the geometrical progression of interactions was highest within the city centre buildings. One such example is illustrated in Seaver's description of the artisan joiner, Nehemiah Wallington: 'As a householder and artisan, Wallington had duties toward family, and kin, servants, neighbours and customers. His social responsibilities took him out of his closet and down to his parlour, his shop and the streets of London beyond.'[182]

This analysis of 'population density' and 'crowding' in the context of the spread of airborne diseases has produced conundrums. The city centre was considered more healthful than the inner suburbs, despite the relatively high 'density'. The hazards of 'crowding' within this part of London could be diluted amongst the various floor levels but only if the occupants avoided regular occupation of the same rooms. Modern studies suggest where there is an inadequate heating system, it is usual for all members of the household to congregate in the one 'heatable space,' often the living room.[183] Elderly and sick people, with some official encouragement,

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[179] Baer, Housing of the Lesser Sort' p.81.

[180] Harding *et al*, *People in Place*, pp.13-14.

[181] Ibid pp. 24-25.

[182] Seaver, *Wallington's World*, p.45.

[183] Thomas Markus, 'Cold, condensation and housing poverty' in Burridge and Ormandy, *Unhealthy Housing*, p.146. At the time publication Markus was Emeritus Professor of Building science at the University of Strathclyde, Glasgow and has taught and written widely about the relationship of housing and health.

often move their beds into this space in cold weather.[184] To relate such patterns of use in the buildings of early modern London is problematic as such information is not available but consideration of the efficiency of heating within the buildings in Chapter 6 of this thesis may at least offer some material for further debate. With a few exceptions, Power does not consider 'density' a widespread issue in the East End[185] but 'crowding' was evident in areas of the relatively wealthier West End.[186] Thus, the potential for 'conduction' of airborne pathogens was intensified in the wealthier areas of the city centre and the West End without tangible increases in mortality. Landers has considered the reasons for the decline in virulence of waterborne diseases and this could also apply to both enteric and airborne diseases. Although density and 'crowding' provided conditions through which enteric and airborne diseases could spread, the degree to which it was realised in practice depends on the presence of a specific pathogen and its ability to ultilise the relevant environmental pathways.[187]

4.4 Fundamental physiological requirements

As noted in Chapter 1, physiology is the study of the physical and chemical processes that take place in living organisms during the performance of life functions. In the context of this thesis, consideration is given to the possibility that low temperatures, poor ventilation and lack of daylight within the dwellings may have contributed to failures in the function of vital respiratory organs. With regards to heating in the early modern era, Robert Clavering wrote in his 1779 *Essay on the Construction and Building of Chimneys* that' Our necessity for chimnies in this climate is absolute.'[188] Clavering included a historical account of poor standards of heating throughout this study period. As noted at the start of this thesis, in 1639 the judge Robert Monson

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[184] For example the leaflet issued jointly by Age Concern Scotland and South of England Electricity Board, 1990).

[185] Power, 'East London housing, p.244.

[186] Power 'East and West' p.174.

[187] See Landers, *Death and the Metropolis***,** in his analysis of waterborne disease, p.36.

[188] Robert Clavering, *An Essay on the Construction and Building of Chimneys*, (London, 1779, reprinted by Gale, ECCO Print Editions, U.S.A. 2009), p.13.

recognised the importance of ventilation and lighting within buildings for good health.[189] Monson's treatise included the arguments of four lawyers or 'famous sages' of the Common Law, which focused on the right to light to properties. Common Law was discussed by the lawyers in the context of 'power and extent of customes in Cities, Townes and Corporations...' The Customs of the City and proclamations were pursued in the Common Law tradition. The four 'sages' were divided in their opinion about the right to light. Only two of the lawyers agreed with Monson in viewing the loss of light from a health aspect, with one stating that without light 'no man can live, and a house lacking light, is rather a dudgeon than a house.'[190] Consideration is now given to the extent the physiological requirements of heating, ventilation and light were addressed by statutes and environmental law.

4.4.i Heating requirements

Of the many important aspects of healthful housing, probably none is more important in the temperate climate zone than the need to provide and maintain a thermal microclimate within a dwelling. This is not only required to fulfil all of the basic physiological requirements of the occupants, but also to provide for thermal comfort, especially for the elderly, the very young and those persons who may be handicapped or ill.[191] Burridge and Ormandy have drawn attention to how numerous studies of housing in the modern era have concluded that adequate warmth in the home is also necessary to ensure that condensation and mould growth do not occur.[192] Despite this awareness of a potential source of building-related illness, there is no requirement in building or environmental health standards that a home in the twenty first century should contain a central heating system. It should therefore not be a surprise that the provision of heating was not a requirement of early modern building policies and yet

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[189] Monson, A *Briefe Declaration*, p.1.

[190] The third judge viewed the loss of light as the theft of a commodity and the fourth was concerned that the out-right ban on window blocking would prevent development on city plots where demand was high, Monson, *A Brief Declaration*, pp.2, 11-13 and 21-4.

[191] Mood, 'Fundamentals of Healthful Housing', p.326.

[192] Burridge and Ormandy, *Unhealthy Housing*, Chapters 6 and 7.

the building codes in Paris did make provisions for chimneys within even the most modest of dwellings.[193]

In modern Britain there is a pronounced increase in mortality from cardiovascular and respiratory disease during the winter. About half of excess winter deaths were certified as being caused by coronary or cerebral thrombosis. One of the underlying causes for this may be an increase in blood viscosity and haematocrit in the cold.[194] The effects of heat, cold, clothing and shelter upon humans also have been researched and ranges of 'operative temperatures' and 'relative humidities' have been developed. For all practical purposes, the operative temperature is the mean of the ambient temperature and the radiant temperature. In general, thermal comfort enjoyed by most occupants involved in sedentary activity is as follows:

	Winter	Summer
Operative Temperature	20.5-24 degC	24-26 DegC
Relative Humidity	30%-70%	30%-60%[195]

Under winter conditions, in order to obtain the required operative temperatures without having excessively high ambient temperatures, the thermal insulation quality of the building fabric would have to be high and the performances of timber-frame and brick-built buildings are considered in the next Chapter.

Despite the lack of statutory or environmental law requirements pertaining to the provision of heating, the Treswell plans show that by 1600 even the smallest houses in London possessed a chimney and had several heated rooms. Graunt considered that the chief problem represented by London's growth was air pollution caused by the increase in the burning of 'Sea Coals.' It is likely that he would have been aware of Evelyn's *Fumifugium*, written a couple of years earlier, which

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[193] Ranum, *Paris in the Age of Absolutism*, p.103.

[194] K.J. Collins 'Cold- and heat- related illnesses in the indoor environment' in Burridge and Ormandy (eds.) *Unhealthy Housing*, pp. 120-1. At the time of publishing Collins was Honorary Senior Lecturer at University College and Middlesex school of Medicine, London University. He was a member of staff at the Medical research Council.

[195] Ibid.

attributed the burning of sea coal to the carrying away of 'multitudes by languishing and deep Confumptions, as the *Bills of Mortality* do Weekly inform us.'[196] Evelyn, along with other contemporaries, laid the cause of this air pollution at the door of industrial processes, notwithstanding evidence given above regarding the number of fireplaces, even in the most humble of dwellings. Weinstein has observed that attempts to control nuisances caused by smoke had been pursued by the City since the middle-ages but Elizabeth I was reported to have been "greatly grieved and annoyed by the taste and smoke of the sea-coles" in 1578. In this particular case the source of the sulphurous smoke was brew houses near Westminster Palace.[197]

In 1595, one Thomas Owen proposed to transport smokeless coal and anthracite to London from South Wales in order to rid the metropolis of smoke. None of the attempts to replace sea coal as a fuel was successful, and significantly, by 1600 it was in use in the houses of the upper classes, owing to the increasing scarcity of wood.[198] It is a matter of conjecture in establishing the type of fuel used by the poor, labouring and artisan classes but inferior quality substitutes were likely. Would such knowledge of the type of fuel burnt add to our investigation into building related illnesses? In consideration of the risk to health through smoke pollution throughout London, Harding argues that in many cases the 'smoaks and stinks' would have exacerbated symptoms, rather than causing or spreading specific disease.[199]

Once a chimney was built, and a fireplace used this did fall within the remit of environmental law in terms of using fire-resisting materials[200] and Nuisance created by smoke. In 1676 the Surveyors' responded to a grievance by Messrs. Allen and Lyme and 'other inhabitants in the parish of St. Mildred Virgin' who complained that a Mr. Clark 'hath built a shedd of timber and boards in the church yard of the aforesaid parish' where 'smoke coming out of the said shed [was] to the annoyance of

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[196] Evelyn, *Fumifugium*, p.30.

[197] Weinsten, 'New Urban demands', p.32.

[198] Ibid.

[199] Harding, 'Housing and Health', p.39.

[200] Schofield, *Medieval London Houses,* 151.

the Neighbourhood.'[201] It is the performance of the fireplaces in terms of generating heat to meet the physiological requirements outlined above that is the focus of this thesis. The performance was very much dependent upon the design and quality of construction, as well as the type of fuel used; statutes and environmental law did not control these aspects. Heating is part of building services and the performance of the open fires is therefore considered in Chapter 6.

4.4.ii The necessity for ventilation

Under the modern Building regulations ventilation has two different meanings when used in conjunction with indoor air quality.[202] The first concerns the provision of fresh outdoor air to occupied areas of a building, and second is the circulation of air within a dwelling but does not necessarily include the addition of any fresh air.[203]

The provision of natural ventilation was specified by the law makers as a requirement. The Royal Proclamation of 1619 prescribed that 'the lights of the Windowes of every whole Story, to be more height than breadth, [so that] the end of the roomes may receive ayre for health…' [204] There would not appear to be evidence that this was pursued further in environmental law. Windows at the opposite ends of a house would provide the most effective form of ventilation but this would be difficult to achieve, particularly in those one-room deep houses illustrated by Treswell, as these small houses were often attached to other buildings. [205] Through ventilation would have been just as difficult in larger house types with the partitions to numerous adjacent rooms impeding the free flow of air. Even accepting some circulation of air, the arrangement of the partitions would produce 'stagnant' pockets of air. This highlights the importance of movement of air within the building.

There would not appear to be any evidence that the 'second meaning' of ventilation was recognised in the study period but the movement of air would have

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[201] LMA COL/SJ/27/471, Vol. II.32, June 20 1676

[202] *Building Regulations 2000,* Part F.

[203] Mood, 'Fundamentals of Healthful Housing', p.328

[204] The Proclamation of 1619; Knowles and Pitt, *The History of the Building Regulation*, p.20; 'James I: *Calendar of State Papers Domestic: James I, 1619.*

[205] See the house types summarised by Schofield, *The London Surveys of Ralph Treswell*, p.17.

been achieved through other means. As noted in the next Chapter, structural movement in buildings would have caused cracks in the fabric and gaps would have opened up between wattle and daub and timber frames; ventilation would have therefore occurred by filtration. Chapter 6 assesses the extent of ventilation through the use of open fires. The provision of fresh air within buildings may on some occasions have been in conflict with the many contemporary miasmatic theories, for example Thomas Sydenham (1624-1689) held the view that epidemic distempers were due to miasma arising from the earth.[206] The extent to which occupants of buildings would have been encouraged to close up their windows during epidemics is unclear. As will be discussed in Chapter 6, the lack of ventilation brings with it dampness, and the propagation of mould and harmful spores circulating in the internal environment.

4.4.iii Rights of light

Building pathology studies have observed that the penetration of direct sunlight into dwellings produces favourable psycho-physiological effects on both thermal comfort and biological activity of humans. As noted in Chapter 1, direct sunlight has some bactericidal effect because of the presence of ultraviolet rays. Also, since direct sunlight will contain some infra-red rays, there is usually a warming or heating effect.[207] A healthful house is one in which the occupants are provided with the possibility of obtaining maximum benefit from both natural and artificial lighting to the extent they desire to perform various household and leisure activities. During the day dwellings, or at least the principal rooms of dwellings, should be illuminated by daylight.

The branch of environmental law addressing the provision of light entering the dwellings of early modern London in the pre-Fire period was Custom and Common law. The Viewers' certificates of the pre-Fire period offer detailed evidence of the physical difficulties inherent in the cheek-by-jowl existence of early modern Londoners, with complaints of someone building beyond his property line, or another

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[206] Rosen, *A History of Public Heath*, pp. 80-1.

[207] Mood, 'Fundamentals of Healthful Housing', p.329.

has constructed a new house so close to a neighbour's dwelling that all access to light and air has been cut off to the latter. The increase in the number of right to light cases during the study period confirms the expectations of London's population but does not necessarily indicate a contemporary association with health. From 1508-58, thirty-eight Viewers' certificates deal with rights of light, twelve of them concentrated between 1550-58. It is notable, however, that 'the custom of London' is rarely mentioned in this context in the pre-Fire period; in fact, the Viewers refer to it explicitly only once, in a certificate, largely illegible, dating from sometime late in the reign of Edward VI:

> The viewers say that the variance is for certain lights there cast out. . . a great glazed window there set forth which ought of right. . . a clerestory right with the same house . . . set up to the soil of the same window and also . . . cast forth on that side of the house of the said party . . . the air after the ancient custom of London . . . at charges of defendant. And further . . . part of the house on the West side of . . . annoy the plaintiff.[208]

Although pictorial and manuscript evidence[209] confirms that many houses had a means of receiving natural light through windows, consideration must be given to the possibility that the increasing sources of air pollution described earlier may have reduced daylight entering into an early modern London's dwellings. It is the loss of light caused by building works, however, obscuring neighbours' windows that invoked environmental law and this is despite Rasmussen observing that there was a better chance for natural daylight to penetrate into the windows of the relatively low rise buildings in the 'scattered' form of London than the high rise 'concentrated' city on mainland Europe.[210] There is evidence, however, that the height of buildings in London's city centre was dictated primarily by land values and ways of doing business; as a result it has been estimated that some buildings in the city centre reached a height of sixty feet in the seventeenth century.[211] Although it is

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[208] *London Viewers* 336 [C.131] 4 April 1551.

[209] For examples of pictorial evidence see Schofield, *Medieval London Houses*, pp.99-105; with regard to manuscripts, these are referred to in numerous inventories in Keene and Harding's *Historical Gazetteer* of Cheapside.

[210] Rasmussen, *The Unique City*, p.26.

[211] Derek Keene, 'Tall Buildings' p.207.

acknowledged that buildings in the poorer suburbs to the east of London were rarely above two storeys,[212] daylight would still be restricted if the street was narrow.

Standards of lighting imposed by Common Law are cited in Monson's treatise: it was argued that two lights on the front and back of a house were sufficient for the entry of air and light.[213] This standard is not referred to in any Viewers' certificates; instead the directive of restoring 'all the lights…before the time of purchase'[214] is the more common remedy, which makes it a question of privileges pertaining to a particular property rather than universal rights. The post-Fire period saw Custom and case law codified in Section XVII of the Rebuilding Act of 1667, which stated that 'that all differences ariseing betweene the said Builders or any others concerning […] stoping up of Lights Windowes […]which may hinder or retard the said building shall and may be heard mediated and by the Alderman of the Ward; or if concerned or cannot determine, then by Lord Mayor, &c.'[215] Significantly, there was to be 'No further Appeal' against such determinations.[216] The Rebuilding Act of 1667 specified maximum heights to the 'four sorts' of buildings, relative to the width of the streets and these are illustrated below (figure 4.02). It would appear that the footprint of many buildings changed in the rebuilding process and even when complying with the statutory requirements, there were cases where one person could not build without prejudice to the 'Ancient light' of another party.[217] This is a significant point in terms of enforcement; in stark contrast to the pre-Fire period, the Viewers and Surveyors of the post-Fire era make frequent reference to the Custom of 'Ancient Light.' Fortified by this early modern form of delegated legislation the Viewers and Surveyors approached disputes with confidence.

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[212] Power 'East London Housing' p.250; Harding *et al, People in Place,* p.27.

[213] Monson, *A Brief Declaration,* pp. 21-4.

[214] For example, see *London Viewers*, 279, [C.74] 12 June 1550.

[215] Section XVII 'Charles II, 1666: An Act for rebuilding the Citty of London.', pp. 603-612.

[216] Ibid.

[217] For example, see LMA/COL/SJ/27/471/Vol.II.97. July 3 1678.

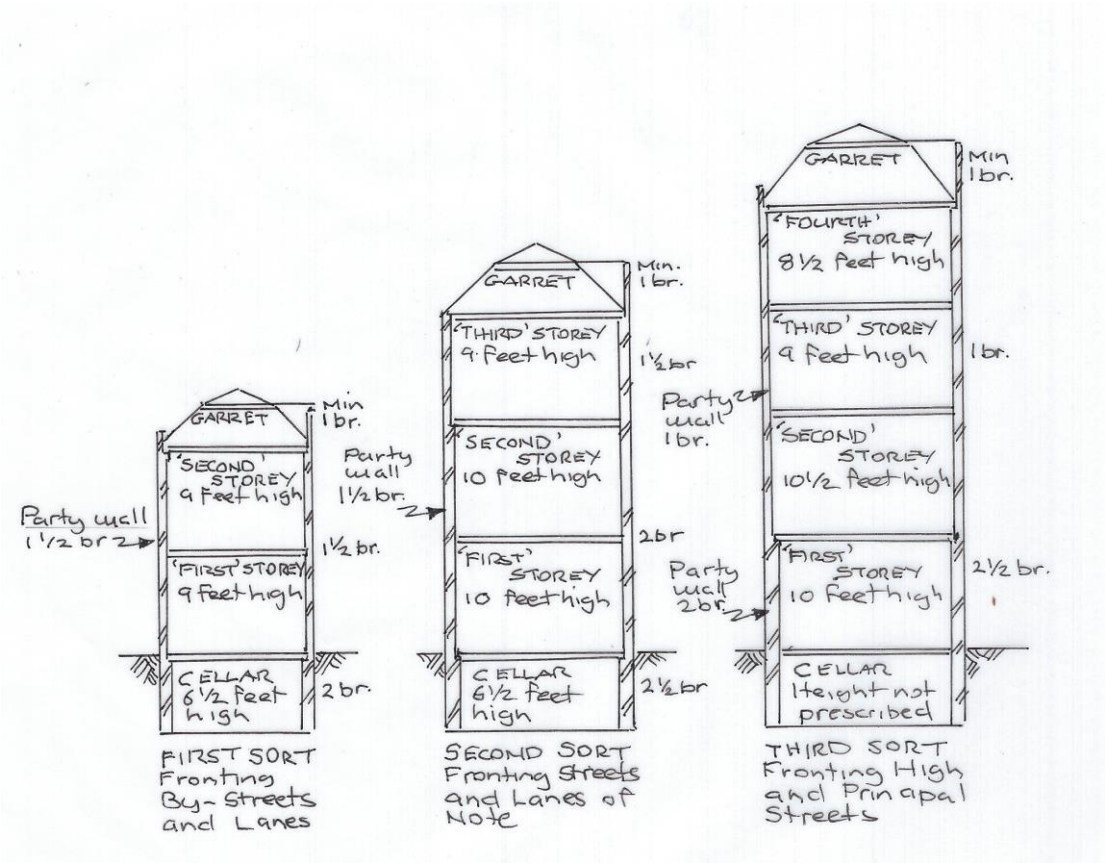

Figure 4.02 A diagrammatic representation of the requirements of the Rebuilding Act of 1667, adapted from Reddaway *The Rebuilding of London*, p.81.

The amount of rights of light cases intensified during this period. My research has revealed 36 cases between 1667 and 1690, reflecting difficulties in rebuilding adjoining properties at different times and to the heights specified by in the Act of 1667.

4.5 Rising and penetrating damp

A premise of this thesis is based on Power's suggestion that perhaps living in damp ruinous buildings is a more tangible and constant hazard to health than overcrowding. This was put forward in Chapter 1 where it was noted that research in the modern era has revealed that damp conditions in a dwelling harbour several microbes that might be damaging to health.[218] It has been noted that viruses that give rise to infection are more common in damp houses and bacteria thrives in moist conditions. Consideration

[218] Sonja Hunt 'Damp and Mouldy Housing' p.78.

has also been given in the opening Chapter to the presence of the dust mite in damp early modern buildings and its possible contribution to respiratory complaints.[219]

According to Hollis, it is likely that rising and penetrating damp would have been present in both timber and brick- built houses.[220] Rising damp occurs within a wall due to the upward transfer of moisture within the building fabric. Penetrating dampness will occur through leaking roofs and gutters, the porous materials to chimneys and walls and the joints around window and door openings. [221] This will be explored in detail in the next Chapter. Schofield has observed a significant damp-proofing custom dating from the thirteenth century, where timber frames with a horizontal sill-beam were laid on low walls to counteract rising damp.[222] The horizontal sill beam acts as a damp-proof course because of grain orientation in the wood. Water absorption across the grain of the sill beam is only a small percentage of that possible along the grain of any posts embedded in the ground. The posts and studs jointed into the sill beam area were therefore protected as long as the joints remained secure.

There would not appear to be any evidence to suggest that the raising of the frame onto a low brick wall was a damp-proofing custom for the benefit of the occupants. Dr. Brian Ridout suggests that the underpinning timber frame with brickwork was a requirement to prevent decay at the base of the frame and therefore was seen as a structural solution rather than a response to health requirements.[223] Chapter 5 includes an analysis of the performance of this form of damp-proofing. The sill beam was not always continuous, however, and individual posts were inserted directly into the ground (see Figure 4.03).

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[219] Ibid.

[220] Hollis, *Surveying Buildings*, p. 558.

[221] Ibid. p. 415.

[222] Schofield, *Medieval London House*, Fig 93, page 82 and figs 165-6, p.143.

[223] Brian Ridout, *Timber Decay in Buildings: The Conservation Approach to treatment* (Spon Press, Reprinted 2004) p.133

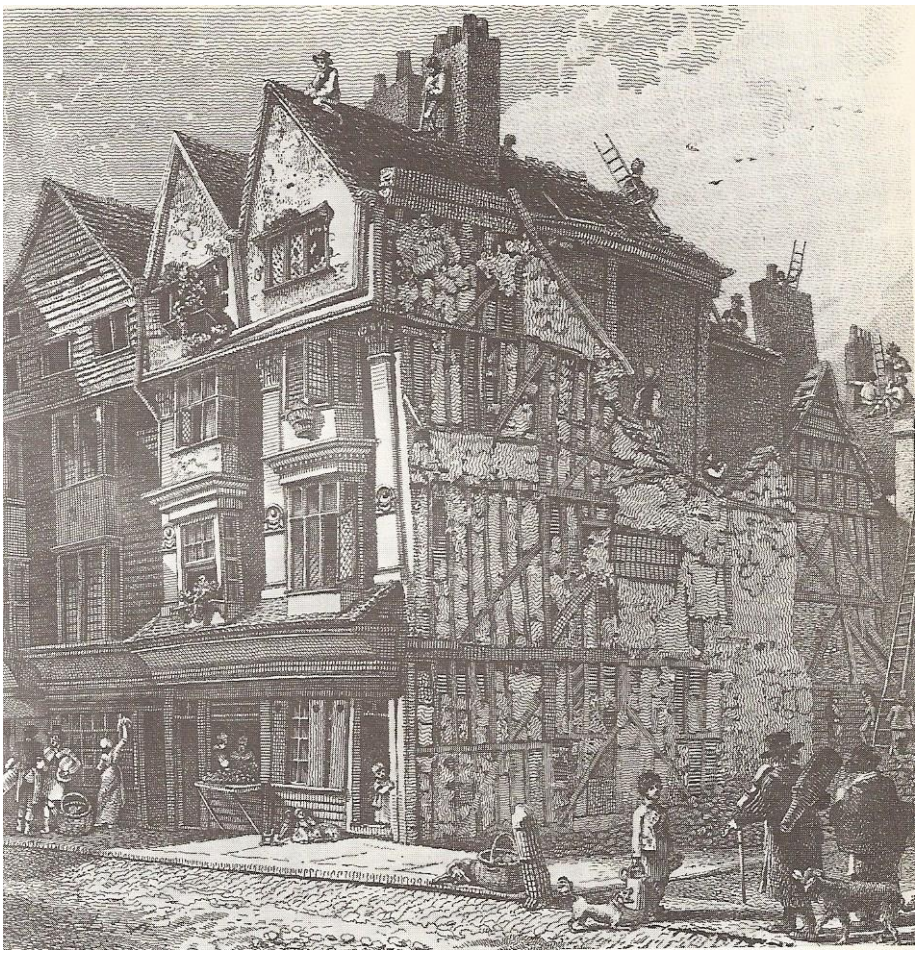

Figure 4.03 Seventeenth-century timber framed houses in Long Lane, West Smithfield, drawn by J.T. Smith in 1795.

This could reflect the fact that the City's Customs were not retrospective and therefore the requirement to lay the frame on a low wall after the thirteenth century would only apply to new construction or repairs to existing structures. It would not be a requirement to raise the frame onto a brick wall if the existing structure was not out of repair. A 1546 Viewers' report on a house in the parish of St Dunstan in the West is one of many examples of such a situation where 'underpinning of the [timber] plates with brick' was required as 'the house is now in decay.' Other sections of the frame were 'in much need of repairs as in plating in sundry places and boarding the floors, rasens, posts, and quarters of timber, which are decayed.'[224] Thus, although a horizontal plate was already in existence, this had decayed, along with adjacent posts

[224] *London Viewers*, No. 195 [B.189] 3 January 1546.

and possibly other vertical timbers inserted around door openings. There was also a contemporary report on a property in Cornhill, which was noted to be 'lack[ing] a…plate at the street door within the said house…also there [was] a groundsill of the same decayed…'[225]

The timber frames apparently supported by posts inserted into the ground in fig.4.03 are unlikely to date from before the requirements of the thirteenth century regulations;[226] the timber posts would not have survived decay up to the time they were drawn by eighteenth- and nineteenth-century artists. This would suggest that the frames had been repaired but not in accordance with the custom of the City. A form of rising dampness in the posts would have occurred. The wall below the frame would have been devoid of any damp proof course and would allow rising dampness up to the underside of the sill beam, which is above the internal floor level and thus exposed the occupants to dampness and health risks. It was noted in Chapter 1 that damp conditions encourage the growth of mould but this is less likely to be found in conditions of rising and penetrating damp in brick and plaster structures, since the salts that emerge within the moisture tend to inhibit its growth.[227]

Damp penetration through roofs, chimneys, gutters and walls have largely been due to the lack of maintenance. The reasons for this could be wanton neglect or economic reasons but Sir William Petty was of the opinion that building prohibition had contributed to the want of repair. He argued that it was unnecessary to curtail London's growth and to discourage building on new foundations as the policy tended to 'fasten the city to its old seat and ground plot […] men being unwilling to build new houses on old sites and so cobble up old houses until they become fundamentally irreparable, at which time they become either the dwelling of the Rascality or in the process of time they return to waste gardens.'[228] Such a gradual deterioration of the buildings would suggest the possibility of the occupants being exposed to building-related illnesses. Maintenance is considered in detail in the next Chapter.

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[225] Ibid, 204 [B.196] 1 September 1546].

[226] The performance of timber post in such locations is analysed in chapter 5.

[227] Hunt 'Damp and Mouldy Housing' p.78.

[228] Petty, *The Collected Works*, p.41.

In terms of building policies there was no statutory or environmental law requirement dealing with the minimum overlap of tiles to resist frequent wind-driven rain from the exposed southwesterly direction. There was also no requirement for damp-proof courses in chimneys. There were frequent reports of rainwater penetration caused by 'spouts' from gutters discharging onto neighbouring properties. Custom and statute sought to address these problems.[229] Custom in the early part of this study period did not stipulate how to set out the timber frame to resist damp penetration; as will be noted in Chapter 5, this relied upon a code of working practice by the carpenter. Similarly, building practice rather than regulations were applied to the external wall finishes; in order to keep the weather out 'lathing and daubing' of the walls was often ordered but no specific requirements stated.[230] Hollis has observed that structural alterations, including the insertion of bay windows and jetties often proved to be a source of damp penetration.[231] Although the Viewers frequently reported and recommended the appropriate structural repairs following these alterations, there was no provision regarding the weather proofing of the joints between the new and original part of the building; it would seem that there was a reliance on good building practice.

A feature known as a 'water table' is referred to frequently by Viewers in the context of damp ingress and was a horizontal ledge along the side of a wall with the intention of keeping rainwater from the base of the wall. The Viewers reported in 1554 on the damp ingress to a property in the ward of Farringdon Without where the garden had been raised over time (presumably through landscaping) and allowed ground water to by-pass the water table 'to the great hurt of the wall'.[232] This Custom of constructing water tables was not, however, included in later proclamations or statutes. The Rebuilding Act of 1667 did, however, recognise the possibility of springs lying beneath buildings. In constructing cellars they were to be ' be six foote

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[229] London Viewers [C.127] 28 November 1552 and Charles II, 1666; 'An Act for rebuilding the Citty of London' Section XI.

[230] For example, see *London Viewers*, 195 [B.189] 3 January 1546.

[231] Hollis, *Surveying Buildings*, p. 405.

[232] *London Viewers*, 171[B.166] 18 August 1542.

and a halfe high if the springs of water hinder not…'[233] There was no specification for dealing with ingress of water into these areas.

A provision to deal with the continued fear of conflagration prompted a Statute of 1707 that may have inadvertently produced severe damp penetration issues. The statute abolished the wooden eaves and the roof was hidden by a parapet wall, with a cornice of brick or stone (figure 4.04).[234] Although there is evidence that parapet walls existed before the Act of 1707, this statutory requirement would have increased their presence.[235]

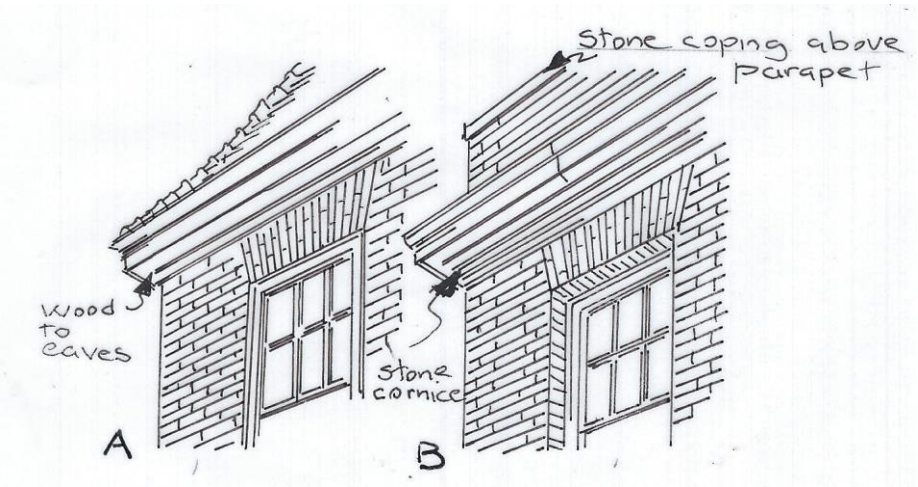

Figure 4.04. Changes in building practice under the Act of 1707; 'A' shows the immediate post Fire style of projecting wooden eaves; 'B' shows the effects of the Act. Adapted from Summerson, *Georgian London*, p.68.

The provision of damp proof courses in parapet walls was not a statutory requirement until 1879.[236] Weather protection to the parapets was sought by placing a stone coping on top of the structure. The arbitrary performance of certain stones in exposed conditions is discussed in the next Chapter but Hollis has observed that even if the stone was impervious, the joints were not.[237] The projecting stone cornice was also vulnerable and in the absence of lead flashings this change in building style

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[233] Sections VII and VIII, 'An Act for rebuilding the Citty of London.'

[234] Summerson, *Georgian London*, p.68.

[235] Ibid. p.69.

[236] The Metropolitan Management and Building Act Amendment act, 1878, in Knowles and Pitt, *The History of the Building Regulation*, p.82.

[237] Hollis, *Surveying Buildings*, p.254-57.

appears to have brought about large-scale problems in terms of damp penetration and decay. The evidence is not provided by the Viewers and Surveyors, however, for it was noted in Chapter 3 that their role was diminishing by this time. Instead, it is the requirements of the Act of 1708, 'for the better preventing mischiefs that may happen by fire' which referred to the 'frequent great damage which happens by constant decay occurring by the setting of brickwork upon timber.' [238] Such failures in statutory requirements would compromise the performance of the building, which is the subject of the next Chapter.

4.6 Conclusion

The aim of this Chapter has been to consider whether the intervention by local and central government into the built environment of early modern London addressed or at least mitigated the spread of enteric and respiratory complaints. This has been considered from two aspects: 'substantive law' which defines the requirements of building standards, and 'procedural rules' by which those standards are enforced. Different areas of building policy were evolving at different rates mainly due to legislation being reactive rather than proactive in nature, reacting to a crisis or shortcoming in the environment. It therefore follows that at any particular point in its evolution, building defects can be attributed, at least in in part, to a failure in building policy requirements in early modern London.

The prohibition of new dwellings and the conversion of existing structures to accommodate the poor was a not just a reaction to concerns pertaining to overcrowding and the spread of disease but was an attempt to address the threat to the City's polity and central government's desire to preserve timber for shipbuilding. Various interests and aims behind building policy appear to have contributed to confused regulations and their policing. Some writers have suggested that the prohibition of accommodation for the poor represented a failure in building policy because it exacerbated the problem of overcrowding and encouraged substandard building practice and maintenance. From this viewpoint intervention through building

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[238] Section XII of the Act; 'House of Lords Journal Volume 18: 23 March 1708', *Journal of the House of Lords: volume 18: 1705-1709* (1767-1830), pp. 548-549. URL: http://www.british-history.ac.uk/report.aspx?compid=29658" Date accessed: 12 December 2010.

policy could therefore be considered inapplicable. The analysis of population density and crowding within dwellings pertaining to public health has posed a conundrum. This analysis has shown that crowding amongst the poor does not appear to have been widespread. Paradoxically, the highest density was in the wealthier city centre where mortality rates were lower. Consideration has been given to the possibility that this population density in the city centre was diluted by the spread of the occupants of the buildings over several floor levels. There is a lack of information confirming that the occupants of these buildings were scattered throughout the building for much of the day. Some doubt has therefore been cast over the extent to which overcrowding contributed to the spread of disease.

From these observations this investigation into building-related illness has considered whether the main source of enteric diseases and respiratory disease was related to the standard of construction of the buildings and services. Although the Rebuilding Act of 1667 attempted to focus on improving the quality of construction, as well as improving daylight and ventilation around the exterior of buildings, there was a lack of any provisions on sanitation. There was no statutory requirement for the collection and disposal of excrement but the Act did specify the removal of surface water, to avoid its pollution. Contemporary references are occasionally made in environmental law relating the provision of water, daylight and ventilation to the health of the occupants of buildings, but more often than not, building policy was addressing a building defect in the context of a ‘nuisance’, interfering with the enjoyment in using a property, or even the loss of an amenity such as light.

It would seem that preventing enteric disease and respiratory complaints were not given priority in early modern building policy despite the point made in Chapter 2 that observation and classification by the contemporary medical profession made possible the more precise recognition of diseases. At the same time, the possibility and importance of applying scientific knowledge to the health needs of the community was given ideological form. Petty and particularly Graunt pursued a quantitative approach to health developed in relation to the political and economic needs of the early modern society. The idea that microscopic organisms might cause communicable diseases also began to be recognised and was mentioned in the building proclamation of 1580, yet this Chapter has shown that none of these areas of growth in early modern science and medicine actually had any tangible effect on

building policy pertaining to enteric and respiratory illnesses. Environmental sanitation and water supply were treated very much as they had been in the medieval period and despite the switch from ‘sticks to bricks’ in building form, there were no specific requirements to prevent damp ingress.

The number of reports produced by the City’s Viewers and Surveyors would suggest that those limited building policy provisions relating either directly or indirectly to health were not being observed in many instances. It is important to stress that we are only made aware of those cases where such offences were noted and action taken. It is difficult to determine whether the failure to observe the requirements was intentional or through ignorance but it is possibly a combination of the two. What is apparent is that the Viewers and Surveyors were under-resourced, and therefore the policing of building policy was compromised. It could be argued that this reflected administration systems that were set up in the medieval period and their seemed little willingness to change this pattern. Among other matters, the next Chapter will consider how these failings in the provisions and enforcement of building policy affected the function and performance of the buildings.

Chapter 5
Failures in the structure and fabric of London's housing

The shorting comings in building policy have been discussed and this Chapter will consider the consequences on the function and performance of the buildings in early modern London. It is apparent from the preceding Chapter that building policies did not regulate many aspects of construction and consideration will also be given here to the contribution made by poor building practice and conflicting user requirements to unhealthy housing. As already noted, the failures in the function and performance may have manifested themselves within three elements of the affected buildings: the structure, fabric or services. This Chapter will explore the first two elements and Chapter 6 will investigate shortcomings in the building services. T.F. Reddaway wrote a generalised account of the performance of the rebuilt city centre after the Great Fire:

> Ten years after the Fire the secular work was complete, and the citizens could take stock of the changes. These were striking…almost revolutionary [with the] wholesale compulsory adoption of a superior building material. Timber and another 'Great Fire' were abolished altogether. The new houses were all constructed of brick or stone, to their great and lasting benefit. Linked to this was the logical and drastic enforcement of better housing standards.[1]

Reddaway was of the view that a 'purge' had taken place through statutory requirements because 'by modern standards, much of the old city would have been classed as a slum'.[2] With the exception of the greater houses built of stout timber frames, filled in with laths and covered with plaster, the meaner sort had often been no more than casings of weatherboards fastened to frames, and the meaner far outnumbered the greater. According to Reddaway 'the much vaulted splendour of Cheapside had been small compensation for the ill-secured rottenness of the alleys behind.'[3] In his opinion, the position had been exaggerated by 'the growing scarcity

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[1] Reddaway, *The Rebuilding of London*, p.284.

[2] Ibid.

[3] Ibid.

of timber, which jeopardized a method of construction sound enough if well maintained.'[4]

On the premise that the massive improvement in the health of populations of urban societies is a consequence of collective intervention in the environment, the renewal and betterment of London's urban fabric after the Fire should have been produced a reduction in mortality levels. Despite Reddaway's favourable account, however, the Bills of Mortality do not suggest any marked improvement in health in the last third of the century.[5] As already noted, respiratory and gastric complaints were prominent and are related to environmental and housing conditions.[6] T.M.M. Baker has questioned the quality of the rebuilt city centre and conjectures that 'Inevitably, in the context where rapid reconstruction was of the essence, there must have been some jerry-building. Many city houses were rebuilt in the Georgian times, and it was not unknown for houses to collapse.'[7] Reddaway has alluded to rotten timbers as the main cause of failure in the pre-Fire buildings of the city centre, which suggests the presence of dampness in the structures. Consideration will be given to the possibility that dampness was also a significant factor in the demise of the post-Fire brick-built dwellings, as well as Baker's theory regarding the speed of construction.

This Chapter is in three main sections. The manifestation of defects, with a focus on dampness in the buildings, is discussed first and a comparison is made with modern buildings. The second section analyses the 'conduction' of dampness into the buildings. The final part considers the likelihood of dampness being retained in the buildings and the effects of constant exposure on the fabric and the health of the occupants.

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[4] Ibid

[5] Harding *et al*, *People in Place*, p.29.

[6] Harding, 'Housing and Health', p.40.

[7] T.M.M Baker, *London: Rebuilding the City after the Great Fire* (Phillimore and Co. 2000) p.16.

5.1 The manifestation of defects in the structure and fabric

Although Reddaway compared the housing conditions of the pre-Fire city centre with the modern definition of a slum, such comparisons must be put into context by considering contemporary expectations about the primary function of a building. The City Viewers expressed the basic functional requirements of buildings in 1551 when reporting on a ruinous timber-framed building in Southwark and directed the tenant to repair the property and 'sufficiently defend the same house, with appurtenances, against wind and rain…'[8] It was noted in the opening Chapter that Robert Monson, a seventeenth-century lawyer specialising in property matters, considered that the first and main purpose of a building was to protect the inhabitants from the extremes of the weather.[9] Shelter was seen as a minimum but essential requirement even of the houses occupied by the poor with Henry Phillippes stating in 1651 that their dwellings should merely be 'sleeping holes to defend them from the injury of the weather …'[10] Thus, the early modern expectation pertaining to the most basic function of dwellings of all social groups was to protect the occupants from dampness and cold temperatures.

In collating the research material for this thesis into building defects onto the Building Pathology Database, the number of categories of defects affecting the function and performance of the city centre's dwellings is largely limited to structure (66%), damp (14%), decay (10 %) and sanitation (10%); this is illustrated in figure 5.01. On the basis that decay is associated with dampness, the above would suggest that 24% of building defects could be attributed to damp in the building structure and fabric. There are other categories that could be included under the headings of shortcomings in the function and performance of the buildings but for the reasons outlined above, the focus of this Chapter is the failure of the dwellings to perform their primary function – to give shelter and a reasonable internal environment- and

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[8] *London Viewers,* 310[C.105] Oct. 7, 1551

[9] Monson, *A Briefe Declaration,* p.1

[10] H. Phillippes, *The Purchasers Pattern* (1651), pp. 10-11, quoted in Baer, 'Housing for the Lesser Sort', p.67.

the possible contribution to respiratory illnesses.[11] Notwithstanding the focus of this investigation, there is some currency in looking closer at the structural defects, which is the largest category in figure 5.01.

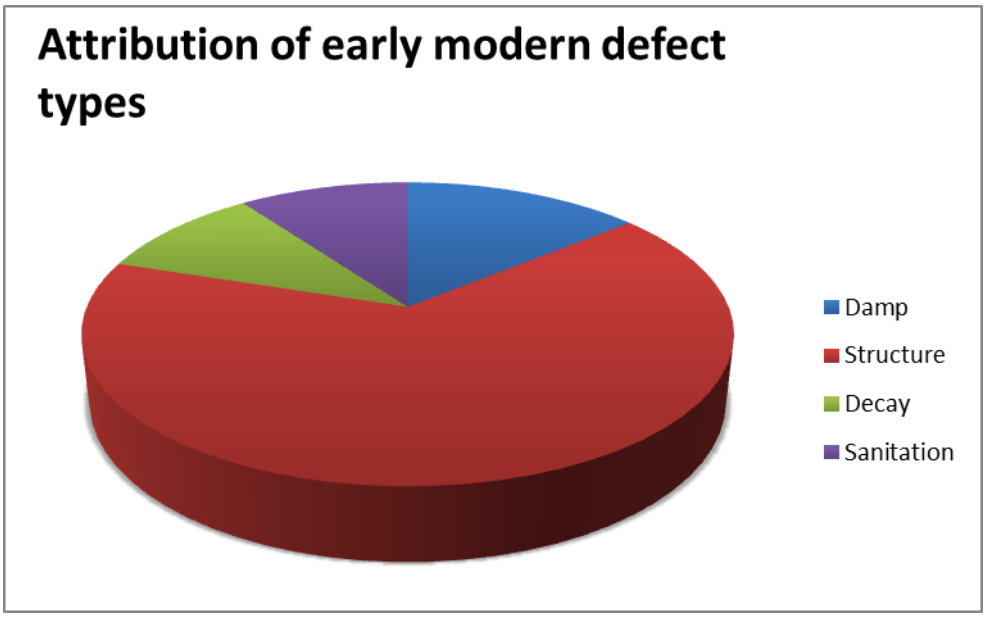

Figure 5.01 Defects in early modern buildings. Source: Loengard (ed.), *London Viewers* (London, 1989); Surveyors' and Viewers' Certificates COL/SJ/27/469-Box 92, COL/SJ/27470-Box 93, and COL/SJ/27471, Vols. I-III (LMA); Keene and Harding, *Historical Gazetteer* ((London, 1987),); Mills, and Oliver, *The Surveys of Building Sites*, Jones and Reddaway (eds.) (London, 1967).

There are reports on structural failures throughout this study period, for example, there was the case of 'A woman, and hir Child, who by the fall of a house in Pond alley [Aldgate], were both slaine…'[12] There is also a description in 1536 of a property in Cheapside as 'a messuage, fallen down and now desolate and a void plot in the 'most chief place' of the city.'[13] Such problems continued through and beyond the study period, with Samuel Johnson observing that London was a place where 'falling houses thunder on your head'.[14] When a messenger ran into a city tavern with an urgent piece of news, the instant supposition was that he had come to warn the

[11] For other function and performance requirements see Watt, *Building Pathology*, pp.16-19.

[12] A case dating from 1616, quoted in Forbes, *Chronicles from Aldgate*, p.145.

[13] Keene and Harding, *Historical gazetteer*, Property 11/1 (113).

[14] Quoted in George, *London Life*, p.83

inmates that the house was falling.[15] These accounts do not give the cause of structural failure but in Watt and Swallow's study of historic buildings they suggest such dramatic collapses could have been the result of poor design, workmanship and materials and the lack of maintenance, as well as changing ground conditions beneath foundations.[16]

Following the recent New Change Excavation in Cheapside, Dave Saxby has been able to provide some useful information on the function and performance of foundations and walls. The early modern brick foundations were constructed to the same thickness as the wall it was supporting and did not have 'footings', that is, splayed or stepped brick work to spread the weight of the building above. Saxby also noted that the medieval walls were often built off Roman remains. Although there was evidence of subsidence to the foundations of some of the Roman buildings below, the early modern foundations were free from structural defects. He has also observed that when the Tudors built in timber off old Roman and early English walls, they used tiles as a means of levelling.[17] With regard to post-Fire building, Saxby observed that in one long cellar near Friday and Bread Street a brick wall was built inside the existing stone walls. This may have been carried out to strengthen the existing walls to support the new brick built structure above. The new wall was also excavated to a deeper level, probably to firmer ground.[18] Although these are individual examples of good building practice, according to Saxby the quality of building in pre-Fire Cheapside was generally of a good standard but showed signs of deteriorating standards in the post-Fire period.[19]

Poor quality repairs and alterations are another source of collapse, as in the case of the London Puritan turner, Nehemiah Wallington and his family who were fortunate to escape death when the front of their house collapsed in 1626 following

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[15] C. Hitchin, quoted in George, *London Life*, p.83. n. 31.

[16] Watt and Swallow, *Surveying Historic Buildings*, pp.60-1.

[17] A personal meeting on the 23 October 2009.

[18] Ibid.

[19] Ibid.

his reckless hacking away of crumbling bricks to a chimney breast with a pickaxe.[20] There is not enough space here to consider other sources of structural failure in detail, however, the close examination of the descriptions given by the Viewers and Surveyors under this category stored on the database does broadly correspond to the above findings of Watt and Swallow. The evidence also reveals that at least 5% of structural defects can be related either directly or indirectly to dampness. Adding this figure to decay (10%) and 14% for damp, suggests that close to one third of the reports on the Building Pathology Database were related to significant damp problems. Examples of such reports are given in Section 5.2 of this Chapter. Widespread dampness was not just an early modern phenomenon for in 1994 the Building Research Establishment ('BRE') published results of their investigations into common defects in the country's building stock, and these are shown in figure 5.02.

In terms of attribution, dampness in modern buildings is sub-divided into penetration (22%), condensation (17%), entrapped water (6%) and rising damp (5%); structural defects include cracking (16%), detachment (13%) and defects in flooring (3%). It is significant that decay and sanitation are not referred to specifically in the data for modern buildings, and one can only assume that they are included in the category of 'other' (8%). Consideration has been given to whether these variations between the Viewers' and BRE reports on defects in the respective early modern and modern periods occur by virtue of the source and intention. The Viewers were reporting on a defect that had already been identified or alleged by a plaintiff. This may have also been the case of the property management sources but the landlords were also instructing Viewers to report on compliance with repairing covenants. In such circumstances there would be an element of investigation and discovery. The BRE sources are also varied as they include reported defects as well as those that required investigation by institutions.

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[20] Seaver, *Wallington's World,* pp.58-59.

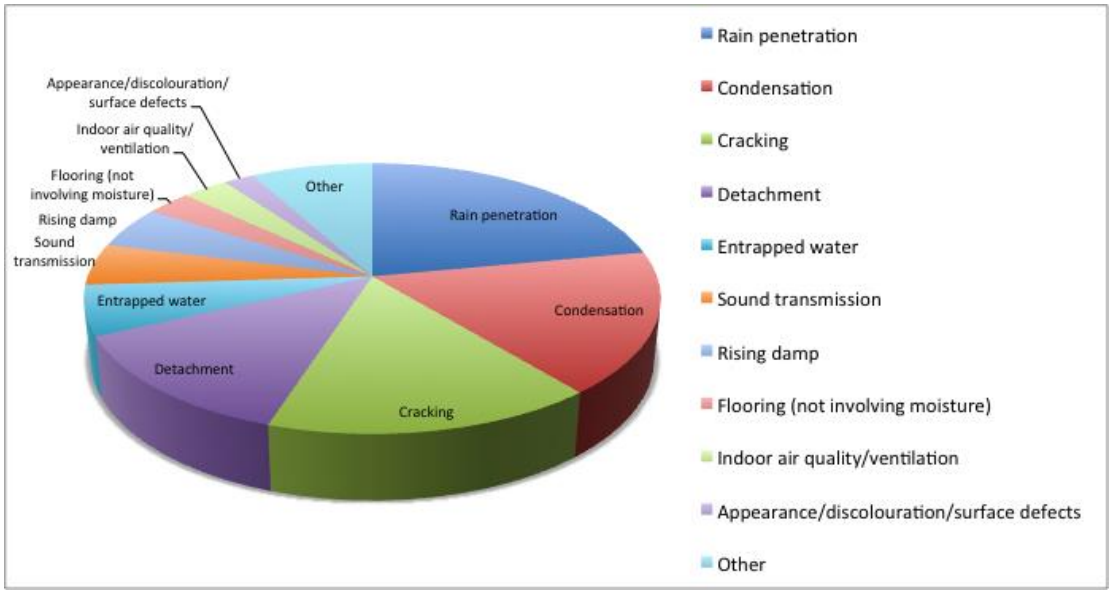

Figure 5.02 Attribution of defects in modern buildings, based on Watt, *Building Pathology*, p.100.

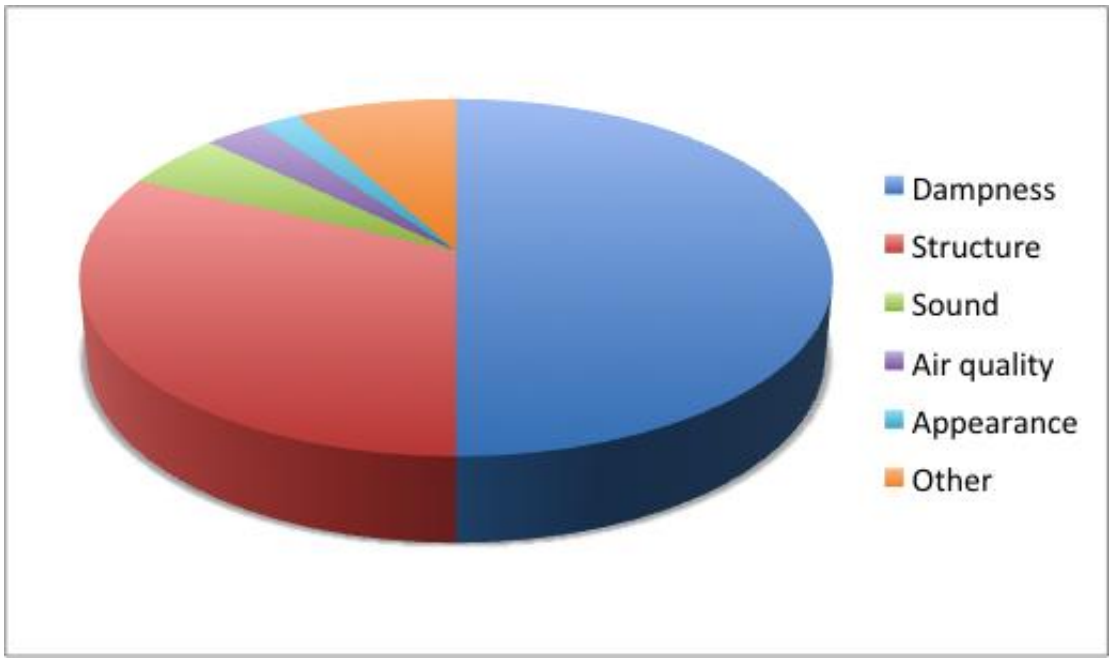

Figure 5.03. The respective sub categories of damp and structure in figure 5.02 have been amalgamated in order that a closer comparison with early modern data in fig. 5.01 can be made.

Trotman notes that many years ago before the BRE was founded, the British Medical Association asked the Royal Institute of British Architects (RIBA) to investigate the causes of dampness in dwellings houses to help them find the prevalence of certain diseases. The RIBA committee found that direct penetration of rain through walls and the lack of a damp-proof course accounted for nearly two-thirds of all cases; condensation accounted for only 2%. Unfortunately Trotman does

not state the year in which this investigation by the RIBA took place but he considers that the sources of damp may have since shifted in relative importance with changes in construction techniques, such as cavity walls and the tendency of houses to be better heated.[21]

Figure 5.03 is a limited attempt to reduce the various manifestations of damp and structural defects occurring in modern structures under their generic headings in order to make some comparison with those of the early modern period (Figure 5.01). Dampness is still a continuing source and it is involved in half of the investigations undertaken over the years by the BRE.[22] With regard to early modern London, sixty-five per cent of the reports on dampness relate to the timber-framed buildings of the pre-Fire period but caution is required in concluding that the post-Fire brick buildings were significantly superior in terms of damp-proofing qualities. As noted in Chapter 3, the Viewers and Surveyors of the post-Fire era were operating within a limited remit and their reports must be considered alongside other contemporary accounts and statutory requirements. Where such evidence is lacking, a forensic technique is applied through *building pathology*.

The evidence of damp was not just confined to one construction type. Reddaway has briefly compared two types, that is, the timber and brick buildings but many of the buildings had utilised a combination of materials: 'the city centre within the Roman-medieval walls ('the 97 parishes'), the immediate extramural suburbs ('the 16 parishes') and the outer suburbs including Westminster […] shared the same building traditions and materials, with timber, brick, and plaster as the main construction materials and clay tiles for roofing'.[23] Variations within these building traditions and the use of materials are therefore considered over time, not least those changes required by statutes. The relative performances of predominately timber-framed and brick-built structures are compared in terms of the conduction and retention of dampness and thermal insulation. These comparisons are summarised in the Building Audits in the Appendix to this thesis. Timber-frames dominated the

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[21] Peter Trotman, Chris Saunders, Harry Harrison, *Understanding dampness: Effects, Causes, Diagnosis and Remedies* (BRE Bookshop, 2004), p.vii.

[22] Ibid.

[23] Harding, 'Housing and Health' p.25.

housing stock in the East End of London before and after the Fire, whereas brick houses were the preferred construction type in the West End throughout the study period.[24]

5.2 The conduction of damp into the buildings

Many of the Viewers' reports describe the same sources of damp as identified in the modern era by the BRE.[25] The following subsections will review evidence of rainwater penetrating down into each main component of the building, through the fabric due to leakages and spillages from rainwater fittings and collecting and rising upwards from the base of the structure. Running parallel to the BRE research on dampness in modern buildings is the previously mentioned work of Watt and Swallow in their surveys of historic buildings, with the most common causes of damp penetration at the top of the building summarised in Figure 5.04. This provides a useful reference point for many defects identified in documentary sources.

The main building materials used throughout the study period were porous but the rate at which the movement of moisture was absorbed would have depended on the severity of the conditions of exposure, the length of time they were subjected to these conditions and the internal pore structure of the materials.[26] Whether the moisture penetrates the thickness of a wall, and manifests itself on the internal surfaces, will depend on the rate at which it is lost through evaporation to the outside air.[27] Thus, a building's aspect and exposure to weather could produce significant variations in the performance of the fabric. A building with a south facing aspect would have been particularly exposed to sunlight for the main part of the day and the driving rain from the south west.[28] This would have caused the expansion and

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[24] Power has collated this information and selected specific areas to illustrate how the proportion of building types and materials varied considerably by geographic areas in Power, 'The East and West', p.170.

[25] Building Research Establishment, GBG 8,1997.

[26] Building Research Establishment, *Treating Rain Penetration in Houses. Good Building Guide 8,* (Garston BRE, 1997).

[27] Watt, *Building Pathology,* p.117.

[28] Staveley and Glover, *Surveying Buildings,* p.182.

contraction of the building fabric through temperature and moisture variations and, in time, the splitting of wood and cracking in render and bricks leaving the structure vulnerable to damp ingress.[29] These effects would be compounded in the case of a building constructed on an elevated south facing site. Different parts of the structures in early modern London would also have been more exposed, particularly tall chimneys, high roofs, parapets and gable walls.

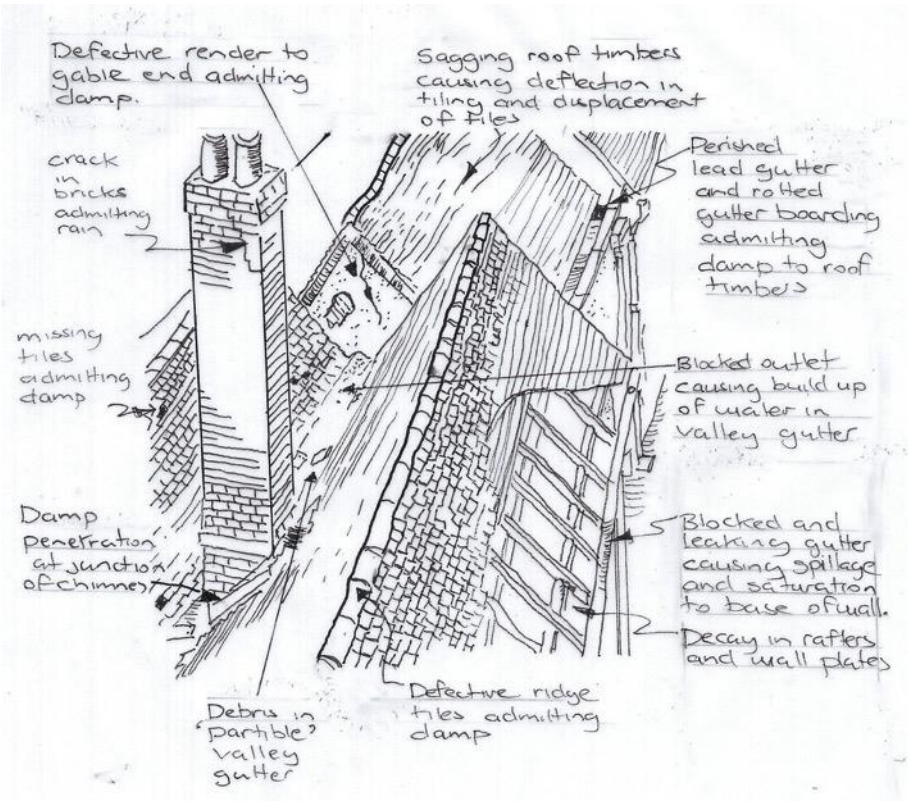

Figure 5.04 Annotated sketch giving simple explanation of defects at roof level typically in pre-Fire buildings, adapted from Watt and Swallow, *Surveying Historic Buildings*, p.88.

The Viewers make occasional references to repairs on south facing elevations. In 1542 two old houses in the Parish of St. Magnus were recorded by the Viewers as being 'both decayed for lack of reparations.' Although the foundations were observed to be 'sunken toward the S'[south] the reason for this was that 'both houses overhang southwards' due to decay in their frames.[30] Extensive repairs were required in 1557 to a south facing elevation to a building in Pudding Lane, in the parish of Saint

[29] Ibid.

[30] *London Viewers* 164 [B.159] 10 March 1542.

Margaret. Despite the house requiring 'reparacions' there was a dispute over the extent and the method of carrying out the repairs. The Viewers were responding to the allegation by the plaintiff that 'a great Capitall mesuage' had been 'defaced with taking down away of an entrie south [wall].'[31] The sources of damp ingress are now considered whilst being aware of the variations produced in the building performance of similar construction types but with different aspects and degrees of exposure to weather.

5.2.i Porous chimney stacks

The vulnerability of chimneys to the effects of weathering is clearly illustrated in figure 5.04. Damp proof courses were not perceived as a requirement within chimney stacks to prevent the downward penetration of rainwater.[32] Repairs were required on a regular basis not only to prevent dampness penetrating directly to the interior, but also to avoid the general deterioration of the bricks and render. It is possible that dampness had led to the crumbling bricks to a chimney breast in Nehemiah Wallington's house in 1626.[33]

Robert Clavering's 1779 historical account on the construction and performance of chimney stacks concluded that building methods and standards did not improve throughout the sixteenth and seventeenth centuries.[34] The performance of open fires within the buildings is considered in more detail in the next Chapter but the interaction with the external environment is clear. The exposed position of the chimney stacks meant that they were prone to deterioration through weathering and atmospheric pollution, leading to the rapid failure of the fabric and eventual loss of stability. Even where the stability was not impaired, Clavering observed 'when part of the top of the chimney is broken down, it causes the chimney to smoke.'[35]

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[31] Ibid. 380 [C.175] 17 September 1557.

[32] Ian Melville, Ian Gordon, and Anthony Boswood, *Structural Surveys of Dwelling Houses*, (The Estates Gazette, Second Edition, 1974), p.78; Watt and Swallow, *Surveying Historic Buildings*, pp. 185-6.

[33] Seaver, *Wallington's World,* p.58.

[34] Clavering, *An Essay*, p.2.

[35] Ibid. p.25.

There are numerous Viewers' reports referring to 'amending of chimneys'[36] and the repairs to these exposed structures are frequently referred to in the *Cheapside Gazetteer*. Repairs to such tall structures, typically difficult to access, could be expensive and labour intensive. There is an example of a dauber who spent six days working on a single chimney stack to a property in Cheapside.[37] In terms of performance, the life span of the chimney stacks is difficult to estimate from documentary evidence. In the case of a property in St. Mary-le Bow, Cheapside it would appear that the performance was reasonable, with reference made to chimney stack repairs on three occasions over a period of one hundred and twenty years.[38] It is possible, however, that repairs were undertaken during the intervening years without being recorded. The lack of maintenance or poor quality repairs would often lead to reconstruction as in the case of the Drapers Company paying for the rebuilding of chimneys to a property in St Mary le Bow between 1567-8.[39] The accounts given in the documentary sources reveal that damp penetration into the buildings through these structures was frequent and prolonged and is the reason for the structures having reached such a dilapidated condition.

5.2.ii Leaking pitched and flat roofs

The primary function of a roof is to protect the building below from the affects of the weather. The basic pitched roof, which was the simplest design to construct, provided a most functional slope to keep out the rain. Cruickshank describes that before the eighteenth century the roof pitch typically ran at right angles to the façade, forming the gable end, which characterises medieval and Tudor buildings. In the early eighteenth century pitched roofs running in the traditional direction were still used, but 'the great gable was softened by hipping the end of the roof.'[40] At various times during the early part of this study period, houses were covered with shingles, boards,

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[36] For example, see *London Viewers,*109. [B.104] 4 July l534.

[37] Keene and Harding, *Cheapside Gazetteer* 'St. Martin Pomary 95/5'.

[38] Ibid. 'St. Mary le Bow 104/14'.

[39] Ibid.

[40] Cruickshank and Wyld, p.166.

clay tiles, blue slates, stone slates or lead.[41] In terms of the performance of these various roof coverings, Staveley and Glover have produced data on the life spans based on modern research into the performance of materials; this is summarised in Figure 5.05. Stone and slates are rarely mentioned in the study period and boards are occasionally referred to with regard to sheds. Tiles were the most common form of roof covering in the study period and therefore require a more detailed analysis.[42]

Figure 5.05: Life span of roof materials (from Staveley and Glover, *Surveying Buildings*, pp. 63-64).

Covering	**Life span in years**		
Good quality flat lead roofs	80	-	100
Hand-made clay tiles	60	-	70
Local Stone (depending on porosity)	10	-	100
Good quality Welsh slates	60	-	90
Poorer quality slates	40	-	60
Shingles (wood)	5	-	30

The use of tiles dictated the pitch of the roof because, in contrast to slates, they required a steep pitch to keep rainwater out; this forced builders to use steep pitches over relatively narrow spans. According to Cruickshank this meant that even the smallest terrace house had to be topped with a 'towering cliff of tiles on a great gable end' and to avoid this, the early eighteenth-century builders devised a method of covering the span with two or more scaled-down pitched roofs, called after its shape, the M roof.[43] The ridge of the M roof generally ran at right angles to the façade for if it ran parallel, it simply became a double-pitched roof. Occasionally, if a sole builder developed a terrace, the M roof could run across the entire length terrace with very little relationship to the individual house units. The M roof, with its pitch at right angles to the façade, emerged in the late seventeenth century.[44] Its one big disadvantage was that it was only a roof, a basic coverage, whereas others such as the double lean-to roof and especially the mansard could take rooms and be lighted with dormers. McKellar has drawn our attention to Devonshire Square, off Bishopsgate

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[41] Schofield, *Medieval London Houses*, P.96.

[42] Harding, 'Housing and Health' p.25.

[43] Ibid.

[44] Ibid. p.166.

(c.1680), which was smaller than the squares of the West End but included dormers and flat roofs above the traditional pitched roofs.[45] Amen Court, built after the Great Fire was designed with a mansard roof and dormers (see Building Audit D in Appendix A).

If the steeped pitched roofs were to fulfil their function then consideration must be given to the performance of the tiles. The contemporary view regarding the life span of clay tiles varied from the modern data shown in Figure 5.05. As early as 1467-8 the Tilers successfully petitioned the City for restoration of their franchise. They complained that due to the poor quality of manufacturing, tiles lasted no more than three to four years, instead of the forty to fifty they alleged to have been the former performance standard.[46] A move to standardise the quality and dimensions of tiles in the later fifteenth century provides some detail of manufacture. The Tilers petition stated that tiles should be made with better tempered clay, dug at Michaelmas (29 September) and left until Christmas then cast up so that the marl and chalk in it would break out with the frost; and finally used in the March following. The standard size was to be 10 ½ inches x 6 ¼ inches by at least 5/8 inches thick.[47] According to Schofield the places of manufacture of the earliest ceramic roof tiles in London have not yet been identified, though the clay is local. Tilers were found in St. Sepulchre's parish, on the western fringe of the walled city as early as the thirteenth century but by the fourteenth century the tile-making centres for London had moved further east; digging for clay is recorded in Stepney and Woolwich.[48]

Peg tiles were the principal type of ceramic tile used in London until pantiles were introduced in the mid-seventeenth century. The wooden tile pins seem to have been of oak, and according to Salzman this was an unsatisfactory material and may help to explain the constant need for repairs.[49] The ends of the pegs would be the

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[45] McKellar, *The birth of Modern London*, p.202.

[46] Schofield, *Medieval London Houses*, p.97.

[47] Ibid.

[48] Ibid. Schofield and Lea, *Holy trinity Priory, Aldgate*, p.220.

[49] This conclusion was apparently reached after his discussions with craftsmen. Salzman, *Building In England*, p.234.

exposed end grain, through which rainwater could be absorbed and lead to decay. [50] Alternative means of securing tiles are mentioned in the *Cheapside Gazetteer* with tilers using pins, and roof nails.[51] These nails would have been prone to corrosion and rendered the tiles insecure.[52]

Over their life span the surfaces of the clay tiles in pre- and post-Fire London would have developed lamination to the surfaces. The salts that naturally occur within the clay would have crystallised causing a breaking-up of the surfaces. This natural ageing process would have been aggravated by frost damage, especially on cold north facing slopes. There are several cases where the Viewers have observed 'so many of the tiles and other things of the house […] has broken down by reason of his building there.'[53] Here the Viewers have highlighted the difficulties of carrying out various types of building work without causing damage to the adjoining structures. The variable that is most difficult to assess, however, is the affect of the atmospheric pollution caused by the burning of sea-coal. In view of the contemporary accounts given by Evelyn and Graunt [54] the extent of the pollution was such that the life span of most materials would have been affected and may be a significant factor in the large number of Viewers' reports on leaking roof coverings.

In 1550 the Viewers inspected a defective roof to a property in the Parish of St. Gabriel Fenchurch. The inspection was undertaken in December of that year, possibly when the leaks in the roof were more frequent and the Viewers reported that 'The roof is ready to fall down.'[55] For the roof to become unstable meant that the damp penetration had taken place over a sustained period to bring about decay in the structural timbers; the rate at which wood will decay in the presence of dampness is discussed in Section 5.3 of this Chapter. This particular roof extended over a chamber, measuring '22 ft. in length and 19 ft. in breadth' and the damp penetration

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[50] Watt and Swallow, *Surveying Historic Buildings,* p119.

[51] Keene and Harding, *Cheapside Gazetteer,*' St. Martin Pomary 95/4'.

[52] Watt and Swallow, *Surveying Historic Buildings,* p.119.

[53] *London Viewers* 332 [C.127] 28 November 1552.

[54] Graunt, *Natural and Political Observations,* pp. 94-5;J. Evelyn, *Fumifugium,* p.41.

[55] *London Viewers* 289 [C.84] 23 December 1550.

had also caused damage internally where the Viewers observed 'The chamber over the hall next to the street side is in decay.'[56] The maintenance of this particular property appears to have been poorly managed in contrast to the many Cheapside properties documented by Keene and Harding where frequent reference is made to clay roof tile repairs but occasionally there is evidence of prolonged exposure to damp causing decay in roof rafters and purlins.[57]

Lead as a roof covering was too expensive for widespread use at domestic level.[58] Although it was used in relatively small quantities it was placed in significant positions at the tops of buildings and its failure could produce widespread defects. Sixteenth- and seventeenth- century references to roof leads indicate that some domestic roofs were covered in lead and were flat, enabling them to be used as walking or airing spaces.[59] By the start of the seventeenth century lead was being used for balconies and small roofs, for example the White Bear in Cheapside. A 'lead' or 'leads' are mentioned eight times in the Treswell surveys. Records of property management indicate that these structures were typically rectangular in shape, for example an inventory of a property in St. Martin Pomary was recorded as having 'leads' measuring '34 ft. (10.36 m.) N./S. by 3 1/2 ft. (1.07 m.) and 22 1/2 ft. (6.86 m.) in length by 4 1/2 ft. (1.37 m.).'[60] The disposal of rainwater from flat roofs is a constant maintenance issue for modern as well as historic buildings.[61] Leakages through relatively small but vulnerable roof areas could have a disproportionate affect in terms of damage to the building beneath. Although 'leads' are referred to in property management records, reported defects are rare. Salzman suggests that if laid well the whole roof forms one impervious sheet and unlike tiles, did not require

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[56] Ibid.

[57] For example, see Keene and Harding, *Cheapside Gazetteer*,' St. Mary le Bow 104/14.'

[58] Schofield, *Medieval London Houses*, P.96; Salzman, *Building in England*, p.264.

[59] Ibid. See also Derek Keene 'Tall Buildings'; Precipitation, Aspiration and Thrills' and Christine Stevenson 'Vantage Points in the Seventeenth-Century City', *The London Journal*, (Volume 33, Number 3, November 2008), pp. 201- 216 and 217- 232.

[60] Keene and Harding, *Cheapside Gazetteer*, 'St. Martin Pomary 95/13-15'.

[61] Hollis, *Surveying Buildings* p.169-173 and Watt and Swallow, *Surveying Historic Buildings* pp.121-5.

constant repairs but he confirms that the chief deterrent was the cost of the material.[62] The lead would either be 'cast' in place or laid in sheets; the latter was a more expensive option.[63]

Watt and Swallow highlight the failures in the performance of lead sheet coverings to flat roofs above historic buildings, such as: poor quality joints at the junctions of sheets and other parts of the building; insufficient support to the lead, causing it to distort and split under its own weight; corrosion of the lead by acid-bearing timber, such as oak boarding.[64] It was common practice to put earth or sand between the wood and lead to prevent such corrosion.[65] The above defects would produce gaps and tears in the surface and allow damp ingress, sometimes exaggerated when gutters drained onto these flat roof areas as noted in 1544 where the Viewers specified the 'repairing or renewing the leads [where] the water of the gutter falls upon the leads'[66]

5.2.iii Leaking valley gutters

The pictorial sources of the study period illustrate the domination of an architectural detail of gable roofs meeting at a valley gutter, often referred to by the Viewers as a 'valley drain' or where it was shared between neighbours, as a 'partible gutter.' The Viewers' certificates confirm that these gutters were the sources of frequent leakages.[67] The function of the valley gutter would be to collect relatively large volumes of rainwater from the adjoining roof slopes and drain it towards a spout or very occasionally in the pre-Fire era, into gutters and downpipes. The performance of the valley gutter depended primarily upon the water tightness of the lining material as well as it being laid to adequate gradient. The most appropriate lining material would be lead, due to its durability and if it was laid correctly, that is cast or laid in sheets

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[62] Salzman, *Building in England* pp.262-3.

[63] Ibid.

[64] Watt and Swallow, *Surveying Historic Buildings* p.123; Salzman, *Building in England,* p.265.

[65] Ibid. p.265.

[66] *London Viewers* 182 [B. 177] 12 March 1544.

[67] Ibid. 261[C.56], 332[C.127], 333[C.128], 366 -7[C.161—162], 381[C.176].

with a small number of joints.[68] Failures in workmanship or maintenance could lead to severe damp penetration. The materials from which these gutters were formed were not always specified and the possibility of boards and tiles being used in poor quality construction cannot be ruled out. Exposed boards would clearly have been vulnerable to decay and the joints a potential source of penetrating damp. It has already been noted that tiles cannot provide adequate damp proofing when laid to a shallow gradient.[69]

When the lining material is mentioned in the Viewers' certificates, it is invariably of lead. The Viewers either identify an existing lead lined valley gutter or specify its repair in the same material, and that it should be 'cast' rather laid in sheets with vulnerable joints.[70] Neither the Viewers nor the records of property management refer to these lead lined valley gutters being supported on timber boards; the lead would have required support from boards to avoid it from sagging under its own weight. As in the case of flat roofs, there was a risk of the vegetable acids in the unseasoned wood supports causing corrosion to the lead.

Figure 5.04 illustrates that the source of penetrating damp could be simply the result of debris collecting in these locations, causing blockages and leading to the rainwater overflowing into the structure beneath. The Viewers frequently reported on shared partible gutters where the lead lining material had deteriorated and was to be 'repaired at equal costs.'[71] Panoramic views shown in Chapter 3 confirm that the gables of housing often faced the street with the valley gutter at right angles to the frontage. Although the width of housing was often relatively narrow, the plots were deep by comparison and excessively long valley gutters were required to drain rainwater from the roofs. In order to drain effectively, the valley gutter would need to be laid to a gradient but this would be very difficult to achieve, as in the case of a property in All Hallows, Honey Lane where the valley gutter was recorded as 37 feet

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[68] Salzman, *Building in England*, p.266.

[69] See also Hollis, *Surveying Buildings*, pp.180-2.

[70] For example, *London Viewers*, 366 [C161] 16 April 1556.

[71] Ibid. 378 [C.173].

(11.28 metres) long;[72] another valley gutter to a property in the parish of St. Bartholomew's was recorded by the Viewers as being 31 feet (9.44 metres) in length.[73] A poorly drained valley gutter would be a source of damp penetration and decay in adjoining roof timbers,[74] leading to the type of repairs faced by Wallington.[75]

Despite the frequent problems of leaking valley gutters in the pre-Fire period, they continued to feature in the post-Fire era. The rebuilding of the city centre after the great Fire was piece-meal and the problem of adjoining houses being constructed at different times led to problems of weather proofing. In 1668, the City Surveyors Robert Hooke and Peter Mills noted that a Mr Marriot had built his property adjacent to a house belonging to a Mr Arthur, and had caused damage to the latter's dwelling through 'the lack of a party gutter' on the roof. Hook and Mills specified that 'Mr Marriot ought forthwith make a gutter on the roof of his house, diverting water into a yard.' [76]

5.2.iv Spouts, gutters and rainwater pipes

If the valley gutter was functioning and performing properly it would drain towards a 'spout' or a gutter attached to the walls or eaves of the roof. The material used for the rainwater fittings is not always specified but again the Viewers frequently refer to a 'lead gutter between the houses of the parties'[77] and 'a lead pipe [to convey] the rain water falling into the gutters to the ground.'[78] The Viewers typically specified their preferred functional requirement of gutters in a certificate dating from 1552: 'the gutter to contain 31 ft. in length between their houses and [pl.] so to convey the water that shall there descend into the gutter into his yard.'[79] There is evidence from the

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[72] Keene and Harding, *Cheapside Gazetteer* 'All Hallows Honey Lane, Property 11/5.

[73] *London Viewers*, 332 [C.127] 28 November 1552.

[74] Watt and Swallow, *Surveying Historic Buildings*, p.119.

[75] Seaver, *Wallington's World,* p.58.

[76] LMA COL/SJ/27/471, Vol1.6. July 25 1668; see also LMA COL/SJ/27/471, Vol. III. 29

[77] *London Viewers*, 366 [C.161] 16 April 1556.

[78] Ibid. 314 [C.109] 9 November 1551.

[79] Ibid. 332 [C.127] 28 November 1552.

Viewers' certificates that they were actively driving an improvement in rainwater disposal by insisting upon the installation of rainwater pipes to carry water down to the ground via downpipes, rather than its discharge from spouts at roof level. The latter method was the frequent source of damp penetration into adjoining walls, particularly as neighbouring dwellings were constructed closer as the building density of London increased. It was noted in the preceding Chapter that the building custom of the 'conveyances of waters by gutters and a pipe'[80] was enshrined in the Rebuilding Act after the Great Fire.[81]

Although lead would be a relatively durable material to use in such locations, it is malleable and as already noted, prone to distort and sag under its own weight; in extreme circumstances this would produce splits and cause leakages. The provision of supporting brackets at regular intervals would prevent such defects.[82] The Viewers do not appear to make reference to leaking down pipes caused by the lack of supporting brackets, but they do report on neglect, ignorance and abuse of the buildings in this context. In 1551 they observed in the case of a property in Parish of St. Sepulchre 'two pieces of two pipes of lead lacking in the house, which were cut and taken away; one of the pipes is 8 ft. in length and the other 9 ft.'[83] They observed that 'For lack of the pipes the house is decayed by falling of the water there.'[84] The Viewers read the lease pertaining to this property and noted that the freeholders were to repair the walls, 'as well against wind and rain as all other repairs.'[85] These repairing covenants relate to what is now recognised as the functional requirements of walls pertaining to resisting dampness. The damp penetration through external walls caused by failures in the performance of rainwater fittings is just one aspect to consider next.

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[80] Ibid. 333 [C.128] 14 December 1552.

[81] Charles II, 1666; 'An Act for rebuilding the Citty of London' Section XI.

[82] Watt and Swallow, *Surveying Historic Buildings,* p.185.

[83] *London Viewers,* 301[C.96] 26 May 1551.

[84] Ibid.

[85] Ibid.

5.2.v Timber-frame walls

Although timber-frame buildings were the dominant construction type in the pre-Fire city centre, it was mentioned at the start of this Chapter that the buildings were often a conglomeration of materials. The timber-frame was typically raised off a brick plinth and sometimes incorporated brick and stone walls from former medieval buildings. This and the following subsection of the Chapter are related in that the relative weather proofing performances of timber-framed and brick walls are compared. This comparison is made whilst recognising that timber continued to play an important structural role in the brick buildings, such as lintels over windows and doors openings and bonding timbers incorporated into external walls.[86] The term 'conglomeration' is therefore considered appropriate in describing the construction of walls in early modern buildings, for it will be shown that the combination of materials, in certain locations within the dwelling, did not always produce improved performance.

The erection of timber-frames in the city centre was largely followed through London's Customs leading to minimum sizes of timbers being specified in 1607.[87] As a structural material, wood is strong in both compression and tension and more structurally determinate than brick walls. Despite the variation of frames used in housing of all social classes, including sheds, they all depended crucially upon the strength of their joints, many of which would have transmitted loads (weight) through tension. Oak was the most widespread timber used in building structures, with elm used for boards, doors, window shutters and floors.[88] There is some evidence of the use of cheaper softwood for housing of the poor; 'Fir' is referred to the in construction of a shed in Wapping in 1635.[89] One great advantage of the use of wood in the East End during this period was its local availability.[90] Once the timber-frame

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[86] McKellar, *The Birth of Modern London*, p.159.

[87] Schofield, *Medieval London Houses*, p.142.

[88] Ibid. p.140

[89] Power, *East London Housing*, p.245.

[90] Ibid. The lessee of the manor of Stepney possessed woodland on the demesne, and trees along the riverside were also used for building.

was erected, the spaces between the frame were filled with reeds or small branches (wattle) or thin timber strips (lathes) pushed into slots in the timbers, to support the daub, which was mud and clay strengthened by horsehair.[91] Defoe observed that such houses were 'very properly called paperwork'[92] and Power draws our attention to a 1642 Parliamentary Survey in the manor of Stepney where houses of 'paper' are mentioned and he concludes that the term is an apt comment on the quality of the construction.[93]

We noted earlier that Reddaway considered timber to be inferior in comparison to brick. In his collaborative work with Lorna Walker, reference to the heavy burden of repairs is made to the timber-framed properties in possession of the Goldsmiths in Newgate which had to be rebuilt in the years 1445-6 at a cost beyond the reach of any normal annual surplus from rents.[94] The Goldsmiths' archives provide evidence that such problems continued with their property portfolio into the seventeenth century, and similar problems occurred in Cheapside.[95] Many of the reported failures of the timber structures appear to be caused by dampness. Power has observed that the occasional mention of ruinous tenements in the Parliamentary surveys of East End housing suggests that they were not originally well built, but in his opinion the decay of many was due to their age.[96] According to F.W.B. Charles, however, oak demands only the right conditions and it will outlast most kinds of stone.[97] The performance of oak will be compromised if it is buried wholly or partly within damp brick and stone construction, as witnessed in 1572 where repairs in a brick wall were required 'because the timber of it was very rotten.'[98] Charles has observed that in none of the timber-framed buildings surveyed by him has the fungus

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[91] Pevsner, *et al*, *The Penguin Dictionary of Building*, pp. 146-7

[92] Defoe, *A Tour*, p.103.

[93] Power, *East London Housing*, p.245.

[94] Reddaway and Walker, *The Early History of the Goldsmiths' Company,* p.134, Note 66.

[95] Court Book, 1651-59, p.61, The Goldsmiths' Company, Goldsmiths' Hall, Foster Lane, London, EC2V 6BN and Keene and Harding, *Cheapside Gazetteer*.

[96] Power, 'East London Housing ' p.246.

[97] F.W.B. Charles, *Conservation of Timber Buildings* (Hutchinson and Co., 1984), Chapters 7-11.

[98] Keene and Harding, *Cheapside gazetteer*, Property 11/8B (3).

dry rot ever been found in the oak frame; it has been oak beams bedded in damp brickwork where the decay has developed.[99]

Unfortunately, the joints are the most vulnerable to decay. Defects in wooden structural members, whether at the joints or elsewhere, are crucial to a frame's load-bearing capacity.[100] This marks the significant difference in building performance requirements between brick and timber-framed buildings. The large number of reports by the Viewers pertaining to the failure in the performance of timber, however, indicates that wood does present some special problems because it is food for fungi and insects. Wood is also actively affected by relative humidity that causes it to expand and contract; moreover excessive moisture robs it of its compressive strength. It is therefore extremely vulnerable to decay if it is not kept in the proper environment. The resistance to decay in different types of wood varies widely, with elm particularly vulnerable and unsuitable for building structures, as it is liable to rot quickly from the inside out.[101]

As noted in the preceding Chapter, from the thirteenth century timber-frames with a horizontal sill beam were laid on low walls to counteract damp and decay in the feet of the posts.[102] Despite this, however, illustrations of early modern housing and Viewers' reports confirm that the sill beam and low wall were not always continuous and individual posts were inserted directly into the ground. An example of this omission is shown in figure 5.06, which illustrates the inconsistent use of the sill beam, with an earth-fast post featured to the right-hand side of the building. Examples of Viewers' reports referring to the omission of sill beams have already been given in the preceding Chapter.[103]

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[99] Charles, *Conservation of Timber Buildings*, p.45.

[100] Bernard Feilden, 'A possible Ethic for the Conservation of Timber Structures' in Charles, *Conservation of Timber Buildings,* p.238. Feilden, CBE, DUniv., FSA, FRSA, FRIBA, AADipl. (Hons) was noted for his pioneering restoration of York Minster in 1960s and 1970s.

[101] Ibid., p.43.

[102] Schofield, *Medieval Houses,* Fig. 93, page 82 and figs 165-6, p.143.

[103] *London Viewers* 202[B.196], September 1546

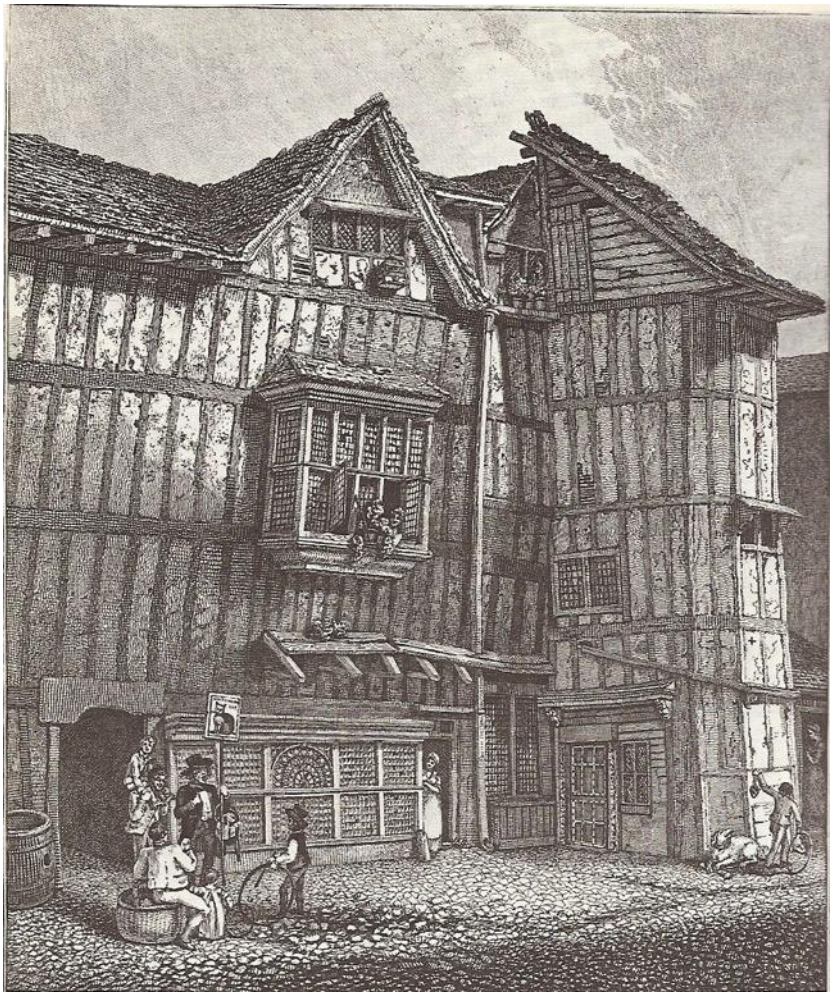

Figure 5.06 Inconsistent use of the sill beam, with earth-fast post featured to the base of projecting part of the building, drawn by J.T. Smith in 1791.

The wattle and daub, together with lath and plaster, 'tended to spring gaps' which let in draught [and damp] until they were patched-up.[104] On this matter, Charles considers that the shrinkage of green-oak, of up to half-an- inch in a 7 inch stud must have concerned the first builders, although he has observed that there was no evidence of the 'habitual crack' between plaster and timber when the original undamaged infill panels were exposed during his restoration work: 'This can only be because in less hurried days the plasterer came back with his bucket of lime to 'make-good', perhaps not only at the end of the maintenance period but each year; or more likely the owner did the job.'[105] This is a significant observation, and demonstrates

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[104] Picard, *Elizabeth's London*, p.51.

[105] Charles, *Conservation of Timber Buildings*, p.105.

the care taken in the preparation and maintenance of the wattle and daub to enhance its performance, for Pevsner *et al* have observed that the material is rarely preserved, unless accidentally baked.[106]

In the early part of the study period, the custom was to set the wattle and daub back a quarter-of-an-inch behind the timber surface, so that the latter would be dried by the winds through 180 degrees and reduce the risk of decay.[107] According to Schofield it became the trend in the second half of the sixteenth century to cover at least part of the frame in a render.[108] The application of the render with loam, finished with a skim of plaster and supported by laths, would not have the same detrimental effects on the wood as modern impervious cementitious renders which trap water and prevent evaporation. In contrast, the more porous early modern render would have allowed some evaporation if damp penetration occurred. As long as the water gain was balanced by water loss, then little damage would have occurred.[109] Thus, maintenance of the render was crucial to avoid rainwater becoming trapped between the render and internal linings, in the area occupied by the frame; timber decays rapidly in a damp and unventilated environment. This is recognised as a problem from surveys of historic buildings in the modern era.[110] Frequent reference is made in documentary sources to defective render or 'daubing' to the main walls, with a risk of entrapped moisture between the render and linings internally. There is no report by the Viewers, however, suggesting that this change in building style brought about rapid deterioration of the frames on a large scale. This does, however, highlight the limitations of the Viewers' accounts referred to in Chapter 3; they were often describing the symptoms and not the causes.

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[106] Pevsner, *et al*, *The Penguin Dictionary of Building*, p. 147

[107] Charles, *Conservation of Timber Buildings*, p.105.

[108] Schofield provides twelve illustrations of rendered covering the frames of buildings in his account of this period; these drawings date from the eighteenth and nineteenth centuries. The limitations of artist as a source material was considered in Chapter 2 but Schofield states that plaster panels have also been recorded on houses from the 1580s and considers that this technique continued into the seventeenth century.

[109] Ridout, *Timber decay in buildings*, p.131

[110] Watt and Swallow, *Surveying Historic Buildings*, p.149.

Weatherboarding was often used to cover the entire timber-frame particularly in the East End of London and Southwark.[111] Weatherboarding, especially in oak or elm, is traditional for barns and it could be argued that this provided superior waterproofing compared to wattle and daub finishes. Those conversions of outbuildings to provide accommodation for the poor may have benefitted from this tradition; the frame would be protected externally and the exposed internal timbers would be dry and ventilated.[112]

Thus, the relatively poor performance of timber-frames compared to brick walls is not so clear-cut and the assumptions that it was an inferior material cannot be fully justified. If used correctly, the performance of oak is enhanced as it wears under the wind and rain in such a way that its surface hardens instead of eroding and breaking down.[113] The skill of the carpenter also played a role in good performance in terms of weather-proofing, if he ensured that the cut surface was set to the outside of a frame. This was done so that the water entering the softer earlywood could not penetrate to the interior of the building because each earlywood half ring would be backed by the latewood.[114] Timber would have been less vulnerable to the atmospheric pollution[115] mentioned earlier by the burning of sea coal which was more acrid and sulphurous than coal produced by modern methods.[116] The use of coal is discussed more fully in the next Chapter.

Mention was made earlier that timber is also a source of food for wood boring insects. The Viewers and Surveyors do not make any reference to wood boring insects and there is no mention of such infestation in the property management records. The work of a John Southall was noted in Chapter 2, who in the eighteenth century manufactured a liquor for killing 'Buggs and Nites' or wood-boring

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[111] See figs. 3.09 and 3.10, Chapter 3, and Power, 'East London housing' p.245; Peter Guillery, *The Small House*, p.165.

[112] Charles, *Conservation of Timber Buildings*, p.105.

[113] Ibid, p.44; see also Ridout, *Timber Decay in Buildings*, p.132.

[114] Ibid, p.44

[115] Ibid.

[116] Picard, *Restoration London*, p.13.

insects.[117] In his 1730 *Treatise of Bugs* he claimed that London had suffered from increasing numbers of bugs for the sixty years preceding his year of publication. He considered the increase in bugs was due to the imports of deal timbers used widely to furnish interiors in houses rebuilt after the Fire. He suggested that the bugs came from hotter climates and experimentation led him to observe that these bugs were selective, and preferred deal timbers to oaks. He considered that the common practice of recycling of old wainscoting, doors and chimneypieces into new dwellings spread the infestation.[118] It is interesting that Southall's experiments revealed that softwoods were preferred by wood boring insects but he did not suggest that the hardwoods were immune from infestation. This would appear to rule-out the presence of death-watch beetle but infestation of timbers by the common furniture beetle cannot be discounted. Although the name death watch was recorded in 1774, by inference it must have existed some time before that date and also possibly the 'little death watch' in the shape of the common furniture beetle.

In the modern era in the United Kingdom, these two wood boring beetles have the worst reputation for causing damage to timbers. According to Hollis the presence of the indigenous death-watch beetle was recorded in the United Kingdom in the eighteenth century and in 1774 it was named *Xestobium rufovillosum.*[119] The noise made by both sexes of the beetle tapping their heads against timber during courtship was believed to be a presage of death.[120] Although death-watch beetle is perceived as the most notorious wood-boring insect known to attack oak, there appears to be no reference to it destroying timbers before the beginning of the twentieth century.[121] Hollis does not consider it a major source of timber destruction in the United Kingdom.[122]

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[117] Cockayne, *Hubbub*, pp.154-5.

[118] Ibid.

[119] Hollis, *Surveying Buildings*, p.448.

[120] Ridout, *Timber Decay in Buildings*, p.37.

[121] Ibid.

[122] Hollis, *Surveying Buildings*, p.448.

It is not certain whether the common furniture beetle or woodworm is indigenous or has been introduced into the United Kingdom. It has similarities to the death-watch and according to Ridout, this has been recognised in older texts as a small death-watch beetle. It was not until 1925, however, that it was discovered that the insect does not 'tap' and the name 'death-watch' was misapplied.[123] The furniture beetle has the same natural habitat as the death watch beetle-the decayed portions of trees but unlike the latter it does not confine its attentions to hardwoods. It is mostly restricted in building timbers to the sapwood of both hardwoods and softwoods and will only attack heartwood that has been softened by fungal attack or is of a species that has little durability, such as birch and beech.[124] Wood boring insects are more active in damp and decayed timbers,[125] and therefore in view of the evidence of widespread damp, there is a strong possibility that they were present in the buildings of the study period.

5.2.vi Solid brick walls

According to Schofield south-east England produced its own bricks from the beginning of the fifteenth century.[126] Purchases of brick figure regularly in company accounts of the fifteenth and sixteenth centuries. The selective use of bricks is evident in the city centre in the early part of this study period. It has already been mentioned that bricks were used for underpinning timber-framed buildings, but they were also used as reredos in a kitchen and occasionally, though rarely, for partitions and the infilling of frames.[127] In his study of the 'East and West' suburbs of early modern London between 1550 and 1650, Power has estimated that 63.6 per cent of the houses in the West End were brick-built, compared to 8.7 per cent in the East.[128] Although it is recognised that Power's analysis is based on a sample of areas in both suburbs, his

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[123] Ridout, *Timber Decay in Buildings*, p.55.

[124] Ibid., p.56.

[125] Ibid p.26 and 131 and Hollis, pp.447-8.

[126] Schofield, *Medieval London Houses*, p.151

[127] Ibid.

[128] Power, 'East and West', p.170.

findings nevertheless provide some idea of the use of bricks as the main structural element before the Fire.

The different clays used in making bricks from various locations in the south-east would not have produced a significant difference in performance and some contemporaries were of the view that it was poor workmanship and the manufacturing processes that caused many building failures. To consider failings in the damp-proofing performance of the brick walls of the dwellings in the city centre requires a detailed analysis of the construction. Section V of the Rebuilding Act of 1667 stated:

> That all the outsides of all Buildings in and about the said Citty be henceforth made of Bricke or Stone or of Bricke and Stone together except Doore cases and Window Frames the Brest Summers and other parts of the first Story to the Front, betweene the Peeres which are to be left to the discretion of the Builder to use substantiall Oaken Timber instead of Bricke or Stone for conveniency of Shopps, And that the said Doores Brest Summers and Window frames be sufficiently discharged of the burthen of the Fabricke by Archworke of Bricke or Stone either straight or circular.[129]

The 'scheme' or schedule in the appendix to this Act confirmed that the walls were to be of solid brick construction and the thicknesses varied from one brick to two bricks, depending upon the category or 'Sort' of house, and the storey height; this was illustrated in fig. 4.02 in the preceding Chapter. Section V of the Act confirmed that timber in the form of oak would be permitted within the construction of the walls. The 'Brest Summers' were horizontal timber beams that carried the wall over wide shop-front openings.[130] Although 'Noe Summers or Girders [were] to lye over the Head of Doores and Windowes' where they were placed over wide shop fronts they were not to 'lye lesse then ten Inches into the Wall' for structural bearing.[131] The 'scheme' also referred to 'Wall plates or raiseing Pieces and Beames.' The terms wall plates or 'raiseing Pieces' appear interchangeable as they had similar functions being horizontal sections of timber providing a bearing for the floor joist. The 'raising pieces' were also known as 'bonding timbers', inserted into the walls at intervals,

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[129] An Act for rebuilding the City of London, pp. 603-12.

[130] Pevsner *et al*, *A Penguin Dictionary of Architecture,* p.69.

[131] *An Act for Rebuilding*, pp. 603-12.

providing a base from which to build another storey.[132] In 1736, Batty Langley considered these 'bonding timbers' would 'most firmly bind together [the walls], so that, even if a foundation be unfirm, they will oblige the settlement to be regular and prevent cracks and fractures…'[133]

The above confirms the conglomerate nature of the construction of London's housing, continuing into the post-Fire period; brick and timber were still used in combination but the ratio had shifted towards the former. The preceding analysis on the performance of oak has revealed that it decays relatively quickly when located within damp brickwork, and its inclusion within the solid walls of the post-Fire city centre is significant. David Yeomans agrees with Batty that the bonding timbers would act to mitigate the effects of differential settlement in the walls but he is of the view that if the wood was decayed, then the structural benefits were lost completely.[134]

Cavity brick walls became a statutory requirement in new construction from 1938 as recognition of the relatively poor weather proofing qualities of solid brick walls.[135] Chartered surveyors in the modern area are obliged to inform their clients of this fact when they are proposing to purchase a property with solid brick walls and to advise them of the necessity of maintaining the exterior elevations in good condition as a first barrier against the weather. Specific advice should be given to the client to guard against leaks or spillages from gutters, downpipes as dampness can penetrate directly to the inside.[136] On this basis, consideration is therefore required on the quality of materials and workmanship in constructing the solid walls in the post-Fire city centre.

The Rebuilding Act did not prescribe a performance standard for the bricks. In the preceding chapter it was noted that the Rebuilding Act adopted many provisions

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[132] See this illustrated in Cruickshank and Wyld, *Georgian Building*, pp. 162 and 190.

[133] Quoted in David Yeomans, ' Structural Carpentry in London Building, in Hermione Hobhouse and Ann Saunders (ed.), *Good and proper materials: The Fabric of London since the Great Fire* (London Topographical Society, 1989), p.41.

[134] Ibid.

[135] H.S. Staveley and P.V. Glover, *Surveying Buildings* (Butterworths, 1983), p.185.

[136] Ibid.

contained in earlier building proclamations, particularly with regard to building in brick, but no reference was made to the proclamation of 1625 which defined the standards required for the manufacture of bricks:

> the said earth bee sufficiently and well wrought and tempered before it bee moulded: And that the Brick makers cause no earth to moulded for bricke, but onely between the Feast of the Annunciation of the blessed Virgine Mary [25th March] and the last day of August yeerely, and that at no other time or season of the yeere. That in the moulding of the said brickes the moulds bee thoroughly and well filled, and not set in moulds in the laying downe: And that they bee sufficiently and well dried before they bee put in the Kilne.[137]

The manufacture of London stock bricks began immediately after the Great Fire, in the 1670s, and the methods of manufacture varied little over the next two and a half centuries. Wren made a comparison between the performance of brick and stone: 'The Earth about London, rightly managed, will yield as good Brick as were the Roman bricks…and will endure in our Air, beyond any Stone our Island affords.'[138] Most of the bricks were made from London Clay, a superficial deposit of brickearth that is naturally the easiest clay from which to make bricks, (that is without the benefit of any mechanical refinements). This brickearth generally and fortunately for London, occurs along river valleys, and it seems from the outset some stocks were brought up the Thames from Kent to the city.[139]

In the rebuilding of London, the City had to consider the manufacture of bricks and lime, vast quantities of which would soon be needed. The City called on the King's Commissioners and the City Surveyors to advise them. The Royal Society, in pursuit of useful knowledge, began at this time to discuss the materials that could be used for building, including the different sorts of clay that were good for making bricks. Unfortunately the results of their findings did not lead to the confirmation or an improvement of a standard for bricks as set down in the building proclamation of 1625 but relied, it would seem, on practices followed by the manufacturer. [140]

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[137] Cited in Knowles and Pitt, *The History of Building Regulation,* p.22.

[138] Christopher Wren, quoted Alan Cox, 'Bricks to build a Capital' in Hobhouse and Saunders (ed.), *Good and proper materials,* p.3.

[139] Ibid.

[140] Knowles and Pitt, *The History of Building Regulation,* pp.21-22.

According to Cruickshank, the manufacturing process produced two different qualities of brick: the place bricks and stock bricks. The place bricks that were cheaper and less-well burnt bricks were used to build the skeleton of the house, and the party walls and piers between the windows. Stock bricks were the facing bricks used in the external brick skin; they were better fired and therefore stronger. Cruickshank notes that the place bricks were used where most of the weight (load) was placed on them in supporting the floor joist built into the inner skin. In other words the strongest bricks were used for the non load-bearing facade, whilst the weaker bricks were doing all the important structural work on the inside.[141] McKellar considers the practice highlighted by Cruickshank represented a 'paradoxical construction concept' and suggests that it was the illusion that the façade presented to the world, rather than the inherent strength of the building, which was of primary concern.[142] There are two points to consider here: first, is the possibility, that the early modern builders felt that the well burnt, harder bricks were more weather resistant; second, if bonding timbers were used in the walls, then these would spread the weight of the structure more evenly across the weaker place bricks and avoid a concentration of loads.

The study of the many reports produced by the City's Viewers and Surveyors in the post-Fire period does not provide a large amount of evidence that the quality of the bricks was substandard. Only one case was found suggesting that the bricks were of such poor quality that they had compromised the structure where in 1685 the Surveyors responded to concerns expressed by a Francis Har[t]ford, 'a turner' regarding his neighbour's house which was apparently 'in great danger of falling.' The Surveyors observed that the party wall was structurally unsound and stated that 'we are of the opinion it was not built with good materials' and recommended rebuilding 'speedily.'[143] Although reference is made to 'bad mortar' in brick walls in another report,[144] the lack of evidence of defective materials in the reports of the

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[141] Cruickshank and Wyld, *Georgian Building*, p.181.

[142] McKellar, *The birth of Modern London*, p.72

[143] LMA COL/SJ/27/471 Vol. III.32 (date 17 November 1685).

[144] LTS IV.80.

Viewers and Surveyors is a striking contrast to the accounts put forward by contemporaries. In his *Complete Body of Architecture*, Isaac Ware considered in 1735 that the housing of the early modern London lacked 'strength' when compared to buildings of earlier ages for they 'stand no longer than their time occasions' and many collapsed before the end of the lease: 'nay some [builders] have carried the art of slight building so far, that their houses have fallen before they were tenanted.'[145] Grossly considered defective materials were the prime cause of the failure in building structures: 'brick is often made upon the spot where the buildings themselves are erected and the workmen make use of the earth which they find in digging the foundations. With this earth they mix the ashes gathered in London by the dustmen…'[146]

Ware and Grossly are describing London in general terms and not specifically the city centre. The discovery of defective materials in the remainder of the post-Fire reports produced by the Surveyors is limited to walls being built in wood and not brick or stone, which was 'Irregular and Contrary' to the Rebuilding Act of 1667. There is a possibility that the materials used in the city centre were of a better standard than those used in the suburbs but this cannot be confirmed. Chapter 4 has raised the issue of the Surveyors being under resourced and the use of defective materials being undiscovered is a strong possibility. However, the lack of site evidence in relation to the number of certificates issued by the Surveyors suggests, that further consideration should be given to frequently cited accusations of Ware *et al* that the buildings were constructed in materials to reflect the duration of the lease. In the absence of significant evidence concerning the use of defective materials, an analysis of the possibility that dampness may have contributed to structural failures is required; constant dampness produced by design defects and a lack of maintenance will lead to the gradual deterioration of even sound materials and well-built structures.

Having considered the manufacture and quality of bricks, it follows that the mortar and pointing within the walls should be closely examined. It was noted earlier

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[145] Quoted in Cruickshank and Wyld, *Georgian Building*, p.3.

[146] Quoted in George, *London Life*, pp. 85-86.

that the Surveyors discovered 'bad mortar' in one particular case in the rebuilding of the city centre. During the study period the mortars were based on locally burnt and slaked chalk or limestone and local aggregates, laid between brick courses to even out irregularities and provide greater adhesion between the bricks.[147] The mortar was, and still is in modern construction, an integral element in the structure of the wall. The process of 'pointing' these mortar joints evolved by the application of a facing mortar to each bed. Pointing had had two functions: first, to throw water off the face of joint and onto the brickwork; second, was for aesthetic reasons.[148] Defective pointing is a frequent source of damp penetration through external walls.[149] Saturated pointing and mortar will increase the risk of moisture penetration internally and will compromise the structural stability of wall.[150]

We noted in the last Chapter that a change in architectural style through statutory requirements might have led to a reduction in the performance of brick and the loss of the advantage it possessed over timber structures. Continued fear of conflagration led to the statute of 1707 that abolished the wooden eaves and the roof was positioned behind a parapet wall, with a decorative cornice of brick or stone (fig. 4.04). As recognised earlier, there is evidence that parapet walls existed before this Act of 1707 but the statutory requirements would have increased their presence[151] and with it, a greater risk of penetrating damp. This was a point not lost in the Gothic revival movement of the Victorian period, where the likes of Ruskin preached the many virtues of northern European Gothic architecture, with its steep roofs and overhanging eaves which were more suited to England's climate than the adoption of a Mediterranean classical style, featuring shallow pitched roofs and vulnerable valley gutters and parapets.[152]

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[147] Watt and Swallow, *Surveying Historic Buildings* p.136; Pevsner *et al*, *The Penguin Dictionary of Architecture*, p.443.

[148] Hollis, *Surveying Buildings*, p.238.

[149] Melville *et al*, *Structural Surveys*, p.125.

[150] Ibid.

[151] Summerson, *Georgian London*, pp. 68-9.

[152] John Ruskin, *The Stones of Venice* Volume I, (1853. Reprinted George Allen, London, 1898) see particularly Chapter 2, on 'The virtues of Architecture.'

Weather protection to the parapets was sought by placing a stone coping on top of the structure.[153] It has already been noted that Wren did not consider stone as durable as brick. Archaeological reports provide evidence that the main stones used in domestic building sites in the early part of the study period were ragstone, chalk and flint.[154] According to Cruickshank and Wyld, however, it is likely that Portland stone would have been used for the copings although there is a lack of evidence to confirm its common use. [155] Portland stone has excellent weathering properties and resistance to pollution.[156] As noted earlier, however, even if the stone was impervious, the joints were not.[157] The top of the parapet was not the only potential source for damp penetration with the projecting stone cornice also vulnerable. In the absence of lead flashings at the junction of parapets walls and parapet gutters, this change in building style appears to have brought about large-scale damp penetration and decay (see figure 5.07).

We have seen in the last Chapter that the Act of 1708 referred to widespread decay of timber buried in damp brickwork.[158] Figure 5.07 graphically illustrates the common cause and symptoms of dampness through this form of construction. The drawing above shows the potential for decay in bonding timbers. In the absence of evidence from the declining offices of the Viewers and Surveyors late into the study period, the reactionary nature of statutory requirements confirmed that the decay of bonding timbers was recognised. An Act of 1765 prohibited the use of bonding timbers, except for short lengths, to act as supports under the ends of heavy timbers.[159]

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[153] Cruickshank and Wyld, *Georgian Building*, p.222.

[154] Schofield, *Medieval London Houses*, p.135.

[155] Cruickshank and Wyld, *Georgian Building*, p.194.

[156] Hollis, *Surveying Buildings*, p.251.

[157] Ibid., pp.262-4.

[158] Section XII of the An+Act+for+the+better+preventing+mischiefs+that+may+happen+by+fire. Date accessed: 12 December 2010.

[159] Cruickshank and Wyld, *Georgian Building*, p.29.

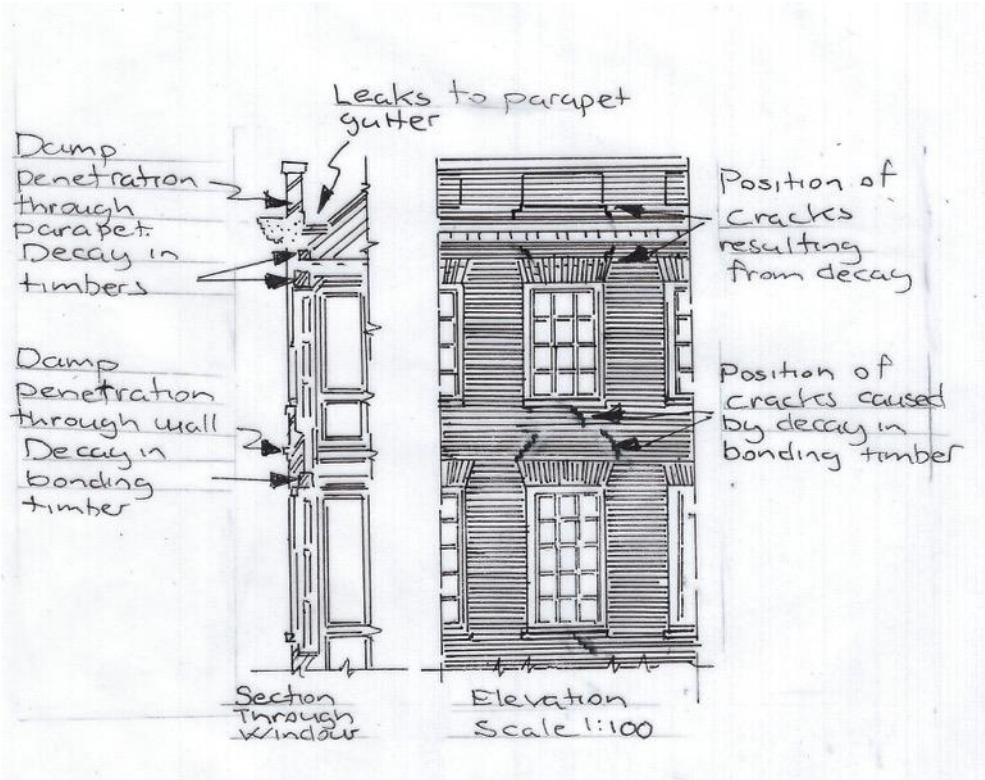

Figure 5.07-Decay to timbers embedded in solid brick walls, adapted from Melville *et al, Structural Surveys of Dwelling Houses*, p.91.

Even though the statutory requirement of 1765 came too late to prevent damp ingress and decay in many existing buildings, it could be argued that a number of structures were still standing without showing significant defects. In an analysis of the rate of decay of the timbers incorporated within brickwork, figure 5.08 illustrates that even in conditions of low humidity, rot will develop. In the sketch below, water penetration through the porous brick parapet has allowed water to travel along the end grain of the timber. The roof timbers will not usually be in anaerobic conditions and the fungi will consume the entire component end as far as the water entering the wall and evaporative loss will allow. This form of decay will continue for some time, even after the supply of water is halted, because the large pores within the bricks are empty of water there is a plentiful supply of ‘free’ water within the wall. It is frequently found that, although several truss and joist ends embedded in the walls have decayed, the roof remains in place unless loadings are altered, because various elements are fastened together and presumably continue to share the load.

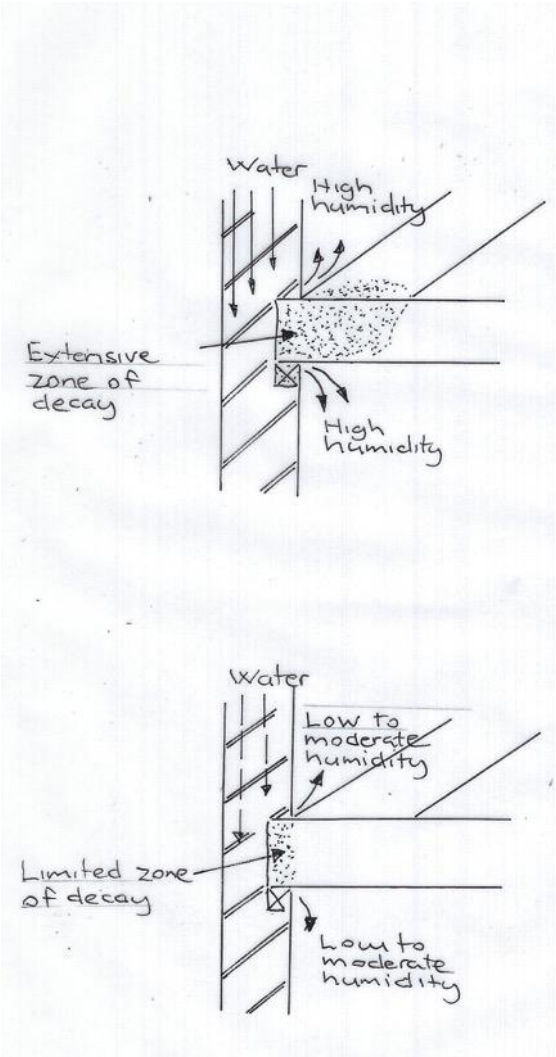

Figure 5.08 Hypothetical decay of truss ends in two different environments, as governed by water availability. In the top sketch large volumes of water enter the wall. Water in the large pores of the bricks is freely available to raise the humidity and saturate the timber. In the bottom sketch smaller volumes of water tend to be held by physical forces with the small pores of the bricks so that the humidities are lower and decay restricted to the embedded section of the timber. Adapted from Ridout, *Timber decay in buildings*, p.131.

According to Ridout, the frame often remains stable and the form of defect shown in the bottom sketch can often give a misleading impression that a balance between damp ingress and loss has been achieved within the building.[160] Building surveys of such properties in the modern era have shown that floor joists built into external walls have suffered from decay caused by penetrating damp through porous walls.[161] Unfortunately, little has been written about the performance of bricks during

[160] Ridout, *Timber Decay in Buildings*, p.129.

[161] Melville, *et al*, *Structural Surveys*, p.91

the early part of this study period but all bricks would have deteriorated relatively rapidly if in the presence of consistent damp conditions and exposed to frost, such as those used in underpinning timber-frames and walls beneath saturated parapets. [162]

5.2.vii Windows and their position in external walls

Damp penetration down from the parapets, roofs and walls could cause decay to the adjoining window frames. The windows could also be a sole source of damp penetration. Unless the windows were properly maintained, decay in the frames, shutters and broken panes of glass could all be a source of damp penetration. Most of the repairs to windows referred to in the records of property management are described in general terms for example, the Skinners Company included general repairs to windows in a property Honey Lane in 1513-14.[163] The City Viewers only describe windows in the context of rights of light issues. Thus, it is not possible to discuss with any certainty the extent to which defective windows may have contributed to damp ingress; this can only be considered by inference and information obtained from investigations in the modern era. In his study of seventeenth-century timber-framed properties outside London, Hollis has observed that the insertion of windows with external projections can result in water being directed into the framework. This often occurs if structural movement has taken place in the framework, causing gaps to open.[164]

Prior to the Act of 1709 the windows were typically flush with the external face of the brickwork.[165] The joint between the brickwork and frame would be vulnerable unless maintained regularly with an application of lime mortar.[166] After 1709 the window frames were to be set back 4 inches (102mm) or one-half brick depth in an attempt to reduce the spread of fire. It was not until the Act of 1774 that the exposed external joint between the window frame and brickwork was eliminated;

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[162] Watt and Swallow, *Surveying Historic Buildings*, p.105.

[163] Keene and Harding, *Cheapside gazetteer*, 'All Hallows Honey Lane 11/9.'

[164] Hollis, *Surveying Buildings*, p.558.

[165] Cruickshank and Wyld, *Georgian Building*, pp.162-3.

[166] Ibid.

the window frame was placed behind the window jamb to give better protection against damp ingress.[167]

5.2.viii Penetrating and rising damp to the base of the walls

High ground levels and paving sloping towards the walls could contribute to penetrating damp at ground and basement level. The repairs to paving is frequently mentioned in the pre-Fire accounts of the properties in Cheapside, but it is only a post-Fire report which suggests that this was considered partly a damp-proofing provision. In 1678 the Viewers responded to 'a complaint being made this day to his Lordship by John Woolhouse that a pavement belonging to Esq, Edward Rudge of the Parish of St. Mary Axe is soe bad... that it letteth the water Soake through Arch and vault of the said Woolhouse aforesaid to the very great Damage of the aforesaid Mr Woolhouse...'[168] Penetrating dampness continued to occur to the base of the walls in the post- Fire period, frequently due to the diversion of water courses, and often associated with building work. In one particular case in St Benet Paul's Wharf in 1667, a Mr Ashenden took action against a Phillip Complin, where the Viewers observed that 'the said Ashenden cellar is overflowed with water and is otherwise annoyed by the said Complin' causing 'very great damage.' The Viewers noted that 'foule and stinking water [was flowing] through the wall' from Complin's property.[169]

Poorly maintained doors adjacent to high ground levels would also be a source of penetrating damp. Although there are frequent references in property management records to 'repair and maintain all doors'[170] there is a dearth of reports on damp ingress through these openings in the main walls. The Viewers did report in 1554 on a blocked gutter to a house in the Parish of St. Sepulchre. Water overflowed 'from the door' into the interior and the house was 'annoyed with filth and water.'[171]

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[167] Ibid.

[168] LMA COL/SJ/27/471, Vol. II 87.9 March 1678.

[169] LMA COL/SJ/27/471, Vol. II.70, Aug. 24 1677.

[170] For example see Keene and Harding, *Cheapside Gazetteer,* 'St. Mary le Bow 104/16

[171] *London Viewers* 351[C. 146] 17 June 1554.

With evidence of dampness penetrating down from the top of buildings to the base of the walls, consideration is now given to the possibility of dampness entering the building by rising up through the fabric from ground level. It was noted in Chapter 4 that rising damp occurs within a wall due to the upward transfer of moisture within the building fabric. The statutory requirements were reactive rather than proactive in nature and it was not until the 1879 Building Regulations that a perceived wide-spread problem of rising damp saw the requirement of an impervious barrier to be inserted into the base of walls. Recent research into the causes of rising damp in modern buildings has revealed eight possible causes, but only one of these is due to the omission of a damp-proof course; this is largely due to the vigorous enforcement of the statutory requirement to provide a damp-proof course by Building Control Officers during the building process[172] and the insertion of damp-proof courses post construction.[173]

Research into the existence of rising damp in early modern buildings is problematic because there do not appear to be any contemporary references to the term. In the early modern context, dampness is a generic term but this should not be used as an excuse for ignoring the possibility that rising damp did exist. It was noted in Chapter 4 that timber-frames with a horizontal sill beam were laid on low walls to counteract damp rising up the posts. This fundamental requirement of early modern building custom is evidence in itself that the phenomenon of rising damp was recognised in practice if not in name. The Viewers frequently observed the symptoms of rising damp in timber posts by referring to decay to the base posts. In 1541, for example, a property in Cornhill was observed as 'lack[ing] a…plate at the street door [and was] decayed.' [174] A post in a kitchen in a house in the Parish of St. Gabriel Fenchurch was recorded as being 'sore decayed.'[175]

Analysis of the performance of posts inserted into the ground (earthfast posts) has been made in the modern era and the results illustrated in Figure 5.09. The

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[172] The Building regulations 2000. See also Watt, *Building Pathology*, p.116.

[173] Hollis, *Surveying Buildings*, pp.420-2.

[174] *London Viewers*, 204 [B.196] 1 September 1546.

[175] Ibid, 214 [C.9] 14 October 1547.

drawing below is based on the results of an experiment on a timber-framed building constructed between 1975 and 1976 by the Butser Archaeological Trust. The performance of the frame was monitored up to the dismantling of the building in 1990 where it was found that the bases of many of the oak posts had rotted away.[176] As noted earlier, it is the decay of the post that contributed to 5% of the structural failures in the timber-frame buildings.

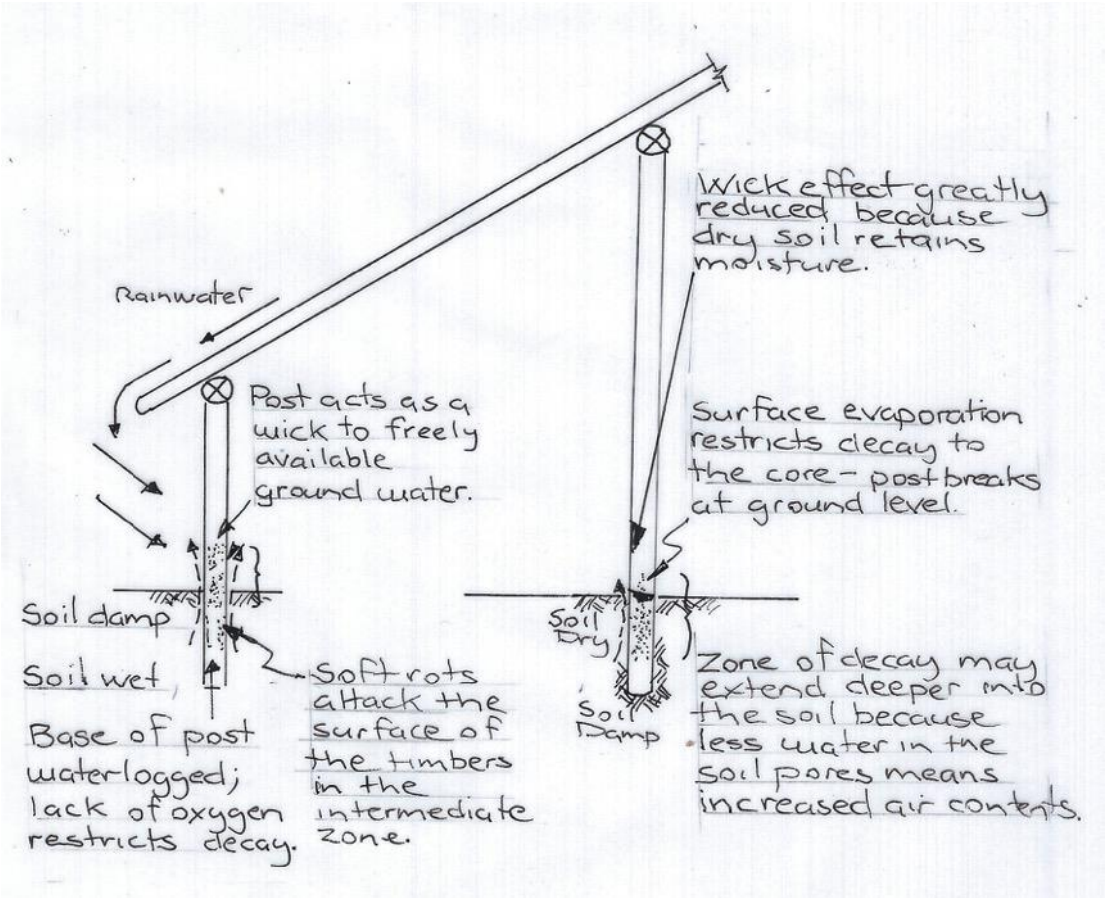

Figure 5.09 Hypothetical decay of earthfast posts in two different environments, as governed by differential water and oxygen availability, in Ridout, *Timber decay in buildings*, p.130.

Figure 5.10 shows a recent repair to a former earthfast post to part of the buildings opposite Barley Hall in York.[177] A sill beam has been inserted beneath the sixteenth-century post, after the bottom section had decayed. In Chapter 4, figure 4.3 shows rising dampness in the posts and also the low brick wall. The wall is devoid of any damp-proof course and this would allow rising dampness up to the underside of

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[176] Ridout, *Timber Decay in Buildings*, pp.128-130.

[177] Barley Hall, 2 Coffee Yard, Off Stonegate, York, Y01 8AR; www.barleyhall.org.uk.

the sill beam, which is above the internal floor level and this would expose the occupants to dampness and health risks.

Figure 5.10. A modern repair to a sixteenth-century earthfast post, opposite Barley Hall, York (photographed 2008).

Rising damp was not just limited to walls; it has already been noted that the solid ground floors would not have been provided with a damp-proof membrane beneath floor coverings.[178] Typical early modern forms of construction were bare or treated earth in the houses of the poor; bricks and tiles and stone and marble in houses belonging to wealthier members of society.[179] The bare or treated earth floors were formed by compacting the earth or using a material such as chalk and gravel, and covering them with rushes and herbs to reduce dust. Variations included the use of clays, ashes and dung.[180] In an earlier period Erasmus confirms 'floors are in general

[178] Hollis, *Surveying Buildings*, p.405.

[179] Watt and Swallow, *Surveying Historic Buildings*, p.158.

[180] Ibid.

laid with a white clay, and are covered with rushes…' [181] By the beginning of the seventeenth century, cellar floors were being laid in brick.[182] The thin floor brick construction and the tiled type, such as pamments, were being manufactured and imported by the fourteenth century.

Only the most prestigious residences could afford impervious floor coverings such as the Purbeck marble laid in the hall of Crosby Place, perhaps emulating the marble floor of Guildhall. Floors of simpler stone slabs are however occasionally mentioned in records and have been excavated in medieval houses.[183] Schofield gives an account of various floor tiles and whilst these could have been impervious, the joints would have been vulnerable to rising damp. The Viewers were quite specific that tiles should be used in the repair of a decayed floor in 1550 to a house in Eastcheap; the tenant was also instructed to 'keep it [the floor] dry.'[184] Floorboards of pine were occasionally laid over a brick floor in the sixteenth or early seventeenth century.[185] There is a shortage of reports on dampness in ground floors from the Viewers and property management records and therefore the analysis has to be moved forward through knowledge about the performance of such floors in the modern era.

Hollis acknowledges the modern debate on the problems of defining rising damp.[186] Whether the sources referred to in this sub-section are rising dampness may depend on which definition of the defect is applied. In Hollis's view, however, the absence of damp-proof courses and membranes in walls and floors respectively would have led to rising damp but its extent would have varied depending on two factors: first, the different environmental conditions on each side of the wall and second the water pressure in the ground. The early modern brick wall would have had an outer face that may have been cold and a relatively warmer surface on the

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[181] Quoted in Brett –James, *The Growth of Stuart London,* p.100 footnote 11

[182] Schofield, *Medieval London Houses* pp.111-113.

[183] Ibid, pp.111-113.

[184] *London Viewers,* 272[C.67], March 14, 1550.

[185] Schofield, *The Building of London*, p.9.

[186] For this account on rising damp, see Hollis, *Surveying Buildings,* pp.415-422 and the Building Research Establishment, *Treating Rising Damp in Houses, Good Building Guide 7* (Garston: BRE 1997).

inside.[187] Any water which would have risen would have brought with it salts from the ground or other building materials, which in themselves would have attracted atmospheric moisture. The warmer air inside the building would have had the effect of drying out the moisture on one side of the wall leaving salts contained within that water on the surface. Those salts would have attracted an amount of dampness from the air; they would also have formed a barrier to the evaporation of water through the wall surface.

Modern analysis has shown that in such situations the dampness would have climbed for two reasons. Firstly because the water extracted from the air would have entered the wall and moved up by evaporation, secondly, because a skin would have formed by the salt deposited on or close to the surface. This would have encouraged the water being sourced from the ground to move even higher up the wall. This upward movement of water in the wall would have been dependent on the water table and this would have generally high in low lying areas around the Thames and London's other rivers but varied elsewhere by seasonal variations in rainfall, and the extraction of water near many of the wells.

In his book *The Building of London from the Conquest to the Great Fire*, Schofield shows a medieval building revealed by excavation. The photograph is of a sixteenth-century house in Lower Thames Street. The building collapsed in the Great Fire. The collapse saved the pine flooring from destruction but significantly it was free from decay in an area where the water table would be relatively high.[188] In other buildings, the laying of impervious floor coverings such as marble may have changed the water pressure from the ground by eliminating the evaporation from the ground surface below the floor that occurred before the covering was applied.[189]

The absence of a damp-proof course does not always mean that the walls will be affected by rising damp. For example, Saxby has observed that the stone lined cellars in the New Change excavation in Cheapside were free from an obvious

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[187] Hollis, *Surveying Buildings*, pp.415-417.

[188] Schofield, *The Building of London*, p.9.

[189] Hollis, *Surveying Buildings*, p.405.

dampness.[190] One could argue that this may have been due to the relatively low water table on this elevated site and yet dampness was clearly a problem in the other areas of Cheapside where in one house, a cellar beneath a shop and part of a warehouse was so damp that it was reported that 'there was a great summer, rotten and decayed with wet.'[191] There is the possibility that the dampness and subsequent decay to the timbers was the result of extensive condensation due to poor sub-floor ventilation; this is recognised as a common defect in the modern era and explains why perforated air bricks are built into the base of walls, at opposite ends of a building.[192] The presence of rising dampness in walls and floors will increase the risk of fungal attack in adjoining floor boards, and such evidence is provided in a 1685 account where a tenant was obliged to remove and replace many of the principal timbers under her kitchen which were decayed or weakened.[193] In another case 'a great summer' was found to be 'rotten and decayed with wet' under the shop and part of the warehouse.[194]

It was noted in Chapter 3, that the property management records confirm that the brick built building in Amen Court, close to St. Paul's Cathedral, has not had rising damp problems and this is despite the absence of a damp proof course. Rising damp cannot exist, however where a damp-proof course is in place.[195] There is an absence of reports that could be interpreted as rising dampness in the brick and stone built structures, particularly those of the post-Fire era. This is not to suggest that rising damp did not exist but, for the reasons noted earlier, it was not differentiated from other forms of dampness. In 1701, Guy Miege observed that the interiors of walls in England were often wainscoted to mask the pervading dampness.[196]

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[190] Personal meeting (23 October 2009).

[191] Keene and Harding, *Cheapside Gazetteer*, Property 1/8.

[192] Hollis, *Surveying Buildings*, p.38; Staveley and Glover, *Surveying Buildings*, p.58.

[193] Keene and Harding, *Cheapside gazetteer*, Property 11/6 (111), Cheapside.

[194] Ibid, Property 11/8 (111), Cheapside.

[195] Hollis, *Surveying Buildings*, p.38

[196] *The New State of England*, quoted in Maureen Waller, *1700*,p.137.

5.3 Damp retention in dwellings and ill-health

As noted in Chapter 2, Landers built a model which comprised 'proximate determinants', two of which relate to the built environment, namely 'conduction' and 'retention'.[197] These determinants have been extended to include physiological as well as pathogenic issues. Thus, the conduction of excess moisture into the building fabric through penetrating and rising damp is likely to have been the most widespread and damaging cause of deterioration and decay to the early modern buildings. The term 'decay' is generic in the early modern context often referring to the deterioration of brick as well as wood and occasionally stone. It has been shown that bricks and mortar would also decay in the presence of dampness over a sustained period of time. As already noted in this analysis, the effects of high levels of moisture on the materials from which buildings are constructed can be devastating as the susceptibility of timber to fungal attack is increased, conditions for chemical and biological degradation are set up, and surface finishes are destroyed.[198]

In order to have had an effect on health the 'potential exposure' to dampness and decay would have to be over a protracted period of time. Establishing the approximate rate at which the decay would occur in the presence of dampness provides a reference point. Such an analysis needs to consider that the ingress of water might have been balanced by 'moisture sinks' through ground drainage, heating, extraction, natural or artificial ventilation. Where such moisture sources were not balanced by appropriate 'sinks', there would have been a potential for moisture to become retained within the construction and cause deterioration and decay.[199] Moisture that is not removed by sinks can be held by porous materials, such as brick, plaster and large section timbers, accumulated rubble and undrained voids to form moisture reservoirs. Such reservoirs can retain moisture for long periods, even after the sources have been removed, and can contribute to long term problems of decay in timber structures and damage to external walling through crystallisation and frost

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[197] Landers, *Death and the Metropolis*, p.13.

[198] Watt, *Building Pathology*, p.114; Watt and Swallow, *Surveying Historic Buildings*, pp. 97-102.

[199] Ibid.

action.[200] Thus, the requirements for the determinant ‘retention’ are met in such circumstances.

Fig. 5.11 shows the life cycle of wood rotting fungi, with the millions of spores present in the air drifting towards the damp surfaces of wood; the development of mycelium and its infestation of the timber; and the subsequent growth of a fruiting body that releases additional spores into the internal environment. Figure 5.11 is a representation of the life-cycle of all types of decay, which are divided into ‘brown’ and ‘white’ rots, according to the colour of the visible damage.[201] These two forms of rot rely on different conditions to propagate but as figure 5.11 illustrates, the occupants would have been exposed to spores circulating in the air, particularly where ventilation was reduced in the sub-division of many buildings and the blocking-up of windows. This suggests a potential pathway for airborne infection in the ‘conduction’ process, initiated by dampness.

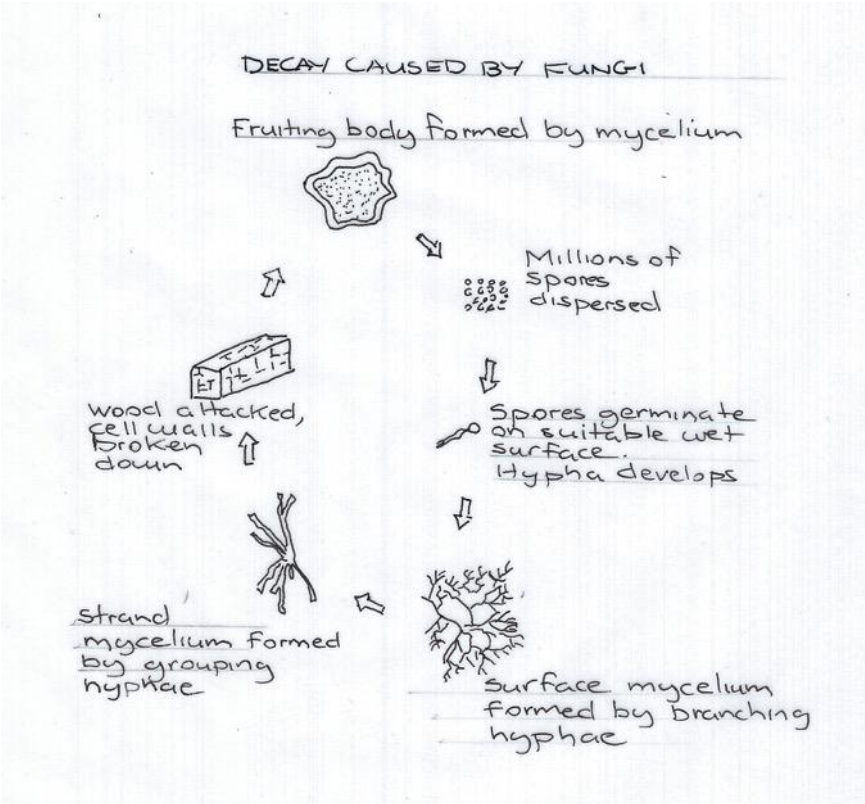

Figure 5.11. Life cycle of wood rotting fungus, adapted from Ridout, *Timber Decay in* Buildings, p.28.

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[200] Ibid.

[201] Ridout, *Timber Decay in Buildings,* p.29.

Wet rot is a member of the 'white rot' group and significantly, as far as Oak and Elm are concerned, white rots are predominately associated with hardwoods, and thrive in wetter buildings than 'brown rot' fungi. 'Brown rots' are more commonly associated with soft woods, which, according to Schofield, were not used in the primary structure of houses in the early part of the study period. Dry rot is a member of the 'brown rot' group and if a building were suffering from this decay, the occupants would not have been subjected to extensive dampness for such an extended period. In the modern era, dry rot is the most infamous form of decay, due to its rate of growth, its extensive destruction of timbers and the ability of its mycelium to spread through brick walls. Its presence in early modern London, however, is doubtful, as Schofield has confirmed that he has never found dry rot in the remains of medieval buildings.[202] According to Ridout, the origin of dry rot in the British Isles remains obscure, with the earliest records of the term 'dry rot' dating from the second half of the eighteenth century. Recent research suggests that it spread from India across Russia to the Atlantic (it is common in buildings across northern Europe), and reached these shores in infected timbers from Europe. [203]

On this evidence, therefore the form of decay in timber-framed houses noted in the Viewers' reports is likely to have been of a wet or 'white rot' nature, progressing inwards from surface of the timber and caused by the actions of wind, heat and water. Wet rot or *coniophora puteana* is more likely to cause decay in oak than any other fungus, but it requires high moisture levels over a long period of time because the rate of deterioration can be slow.[204] Wet rot is able to achieve optimum growth in timbers with a moisture content of between 50 and 60%; it cannot survive if the moisture content drops below 43%.[205] This is significant with regard to health

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[202] A personal meeting John Schofield at the Museum of London, Friday 9th November 2007.

[203] Ridout, *Timber Decay in Buildings*, pp.76-80.

[204] Ibid. pp.94-96.

[205] $$\frac{\text{Moisture content} = (\text{wet weight of wood sample}) - (\text{dry weight of wood sample})}{(\text{dry weight of wood sample})} \times 100\%$$

Formula given in Watt, *Building Pathology*, p.44.

issues; in order for the structural frames, floor boards and joists of the timber houses to have decayed, the buildings and the occupants would had to have been exposed to high levels of dampness for a sustained period of time. The rate of decay is often expressed in terms of the loss of mass over time. After four months of constant retention of moisture, oak would only loose 4% of its mass.[206] Thus, in order for the rot to cause the type of decay necessitating the replacement of timbers and structural repairs to frames, as specified by the Viewers, high levels dampness must have been present for some considerable time.

As noted earlier, there are many Viewers' reports referring to penetrating dampness through shared valley 'partible gutters,' roofs, spouting gutters and ruinous wall surfaces.[207] The extent of damp penetration to bring about decay in hardwoods would have produced high levels of humidity in the internal environment.[208] Modern research has shown that high humidity within the building can satisfy the requirements for the growth of wet rot. At 77.2% relative humidity *coniophora puteana* was noted to be alive after 343 days, dead after 343 days at 62% and could survive 81 days at 21.5%.[209] This research has concluded that most health effects in Britain are associated with high levels of humidity. Mould is produced in such conditions and is attracted to organic materials such as wood, and also leather and fabric used in clothing.[210] Moulds have little effect on timber, although they may spoil its appearance. It was noted in the opening Chapter that large quantities of airborne spores may cause a health hazard and are linked with a range of allergies, infections, toxic reactions, some cancers and psychological symptoms.[211]

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[206] Hollis, *Surveying Buildings*, pp. 467 and 474.

[207] For further examples, see *London Viewers*, for reports on gutters see: 261[C.56], 332 [C.127], 333 [C.128], 366-71 [C.161-C.164], 378 [C.173] and 381[C.176].

[208] Sonja Hunt, 'Damp and mouldy housing' pp.67-86.

[209] Hollis, *Surveying Buildings*, pp. 467.

[210] See Ridout, *Timber Decay in Buildings*, p. 90.

[211] Ibid. Also see Hunt, 'Damp and mouldy housing, pp78-86; William Baker, 'Fuel Poverty and Ill Health: A Review', a paper presented for the Centre for sustainable Energy, (2001), p.9; Hollis, *Surveying Buildings*, p.159 and 418.

5.4 Conclusion

We have seen that close to one third of the reports on the Building Pathology Database were related to significant damp problems. Section 5.2 of this Chapter has identified many elements to the buildings that were vulnerable to damp ingress. The sources used relate to buildings of reasonably wealthy members of society and provides food for thought to the possibility of widespread rising and penetrating damp in the dwellings across all social groups. As noted in Chapter 1, such conditions were conducive to the presence of viruses that give rise to infection and would enable bacteria to thrive. Reddaway considered that the pre-Fire timber-framed building was a sound method of construction, if properly maintained. The evidence would tend to confirm this premise. The sources have revealed that whereas poor design and materials played a role in the demise of some timber-framed buildings, the failure to maintain was the major source for damp ingress; the life span of the most modest structure can be prolonged by maintenance. Although the evidence shows that the wealthy clearly spent money on repairing their properties, it was on a 'corrective' rather than a 'preventative' basis; the defect had already manifested through the decay of timbers.

The lack of maintenance may also have been a significant factor in the demise of the post-Fire brick buildings. The brick elevations required regular maintenance to prevent dampness penetrating directly through the solid walls. The risk of dampness and decay was also exacerbated through poor design on two counts: the building of parapet walls without damp proof courses and building structural timbers into the external walls. The structural and damp resisting performance of oak would be severely compromised in the presence of damp brickwork. Thus, there is much evidence pertaining to the various routes for the conduction of dampness into the buildings throughout the study period.

Buildings will not deteriorate, however, through occasional damp ingress and the physiology of humans will not be undermined by a sporadic roof leak. The performance of buildings and the health of humans are at risk to relatively long-term exposure and the retention of dampness in the buildings is key to this investigation. As noted, all the main building materials used in early modern London were porous but water retention was not just limited to the physical properties of timber, clay and plaster. Exposure to the drying effects of the sun and wind would have produced

variations, as well as different levels of ventilation and the number of ‘sinks’ or natural forms of drainage within the structures. Water could remain trapped in voids of even the most well maintained building, leading to long-term problems. The many cases of decay reported on timber and brick built structures has confirmed that for various reasons, the dampness was retained long enough for the timber to rot and the bricks to weaken. Through *building pathology* techniques the rate of decay has been estimated, confirming that dampness must have existed for a significant period of time and the exposure to the occupants was tangible.

The next Chapter will among other issues, consider the extent to which the propensity for the buildings to retain dampness compromised the thermal insulation qualities of the building fabric and to what extent heat loss was balanced by the standards of heating. Ventilation would also have a role to play, in drying-out structures and preventing the build-up of condensation. It is not possible to state that a particular damp house caused a certain case of respiratory illness, or promoted the development of certain viruses. Nevertheless, considering the evidence provided by the Viewers, Surveyors and records of property management, dampness would have made a significant contribution to building defects and respiratory illnesses.

Chapter 6
Building services and the internal environment

This is the final Chapter in the building pathology analysis, which has so far considered failures in the statutory requirements, along with the shortcomings in the function and performance of the structure and fabric of London's early modern buildings. The relationship between failures in statutory, function and performance requirements has become apparent in this analysis, as well as the influence of 'user requirements'. Although statutes failed to address some poor building practices, consideration has also been given to good standards of workmanship compensating for a lack of regulation in some areas of construction. It has been argued in the last Chapter, however, that building policy and practice failed to address sources of damp ingress into buildings in any significant way. It has also been contended that the presence of dampness was exacerbated by the way the buildings were used or abused. The lack of planned and effective maintenance has figured quite prominently in the manifestation of dampness within the structure and fabric of the dwellings. The analysis of failures of statutory requirements has also suggested that defects would have manifested in the services of the buildings, and is the focus of this Chapter.

It was noted in Chapter 4 that very few services within the London's early modern houses were controlled through statutes and environmental law. Failure to provide adequate water supply and the healthful disposal of excrement would have contributed to the spread of pathogens. Adequate heating and lighting are vital in meeting the physiological requirements of the occupants. As will be shown, ventilation is essential to these two fundamentals of healthful housing. With the lack of wide ranging statutory control over building services, it would appear that their provision and quality within the dwellings was largely dependent upon the respective requirements of the user and building practices. As noted in the opening Chapter, the study of early modern building services brings contemporary 'user requirements' to the surface, particularly the way in which these services were arranged and used.[1]

Health issues relating to defective services remain a concern in the modern era. It has been recognised that building service installations and the comfort

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[1] Watt, *Building Pathology*, pp. 74-5.

standards that they are designed to provide, may have a potentially serious effect on the health and well being of the occupants and users. It is increasingly being demonstrated that certain levels and standards of heat, light and ventilation, and the operation of air conditioning systems are responsible for significant levels of stress and discomfort, and the reliance on artificially serviced or 'tight' buildings has been a cause of various building related illnesses.[2] Some illnesses such as 'Legionnaires disease' from hot water supplies, showers and air-conditioning systems, have been well documented. *Building pathology* has sought to address modern concerns about the indoor environment in which people live and work, and it provides a methodology in assessing building-related illnesses in early modern London.

Apart from a piped water supply to a relatively small number of houses and rainwater disposal via gutters and drains, few services in early modern London were fully 'automated.' The majority of the services were provided manually, and relied on the users of the building, contractors and servants. In the case of larger houses the role of servants could be considered indispensable. The expansion of domestic service in the seventeenth century certainly had a great impact on family life and household composition in the wealthier middling classes.[3] Thus, some consideration of the extent of the quality of services was reliant upon the means and willingness to pay for them is required, together an assessment of the ability of the servants or contractors involved. The distinctions between the levels of services in different social groups, locations and buildings may assist in considering the 'social epidemiology' of housing in Chapter 7.

6.1 The transmission and storage of water within the dwelling

This section of the Chapter will consider how water was brought into the house, the method of storage and the health risks posed. Chapter 4 described how the city centre was fairly well supplied with conduits, bosses, wells and pumps, as well as the New River Company. The majority of Londoners still obtained their water from public conduits or watercourses, including the Thames, or bought it from waterbearers

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[2] Ibid. p.77; see also Hollis and his Chapter on 'Health in Buildings', in Hollis *Surveying Buildings*, pp.151-162.

[3] Harding *et al*, *People in Place*, p.24.

(street sellers) who apparently obtained water from the same sources.[4] Thus, within the relatively small geographical area of the city centre, the variety of water supplies was significant but caution must be taken in assuming that this was governed by income. It was noted in Chapter 2 that despite the intention to attract high-status tenants, the original licence for the development of Covent Garden made no provision for water supply. The outer suburbs in general may have had comparatively good access to decent supplies, in the streams and watercourses flowing towards the city, but the inner suburbs had neither and would have obtained it from remote sources, possibly including the waterbearers.[5]

From the analysis in Chapter 4, it is clear that the quality of water available for use in the homes of different social groups in early modern London must be considered in relative rather than absolute terms. Comparisons between Thames Water and the New River have been made and the application of modern analysis has revealed how contamination of water took place through natural sources as well as those of a man-made nature. It is the level of contamination of water through 'natural sources' that suggests a closer scrutiny is required of the perception that the river supplies of the outer suburbs was more healthful. We have seen in Chapter 4 that even without man-made pollution, rivers may contain a significant number of harmful microbes caused by bacteria and rotting organic materials. There is much modern epidemiological evidence that denotes that safe and sanitary water supply is necessary for the prevention of enteric diseases. According to Mood, studies undertaken in the United States of America in the 1950s and Venezuela in the 1960s still have currency in the modern era in England.[6] The conclusion drawn from these modern studies is that the provision of an abundant, readily available supply of clean, pure water for drinking, culinary purposes and hand washing should not be underestimated as a basic means for the prevention of enteric infections;[7] this is best illustrated in the figure 6.01 below.

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[4] Harding, 'Housing and Health' p.36.

[5] Ibid.

[6] Mood, 'Fundamentals of Healthful Housing' p.307.

[7] Ibid.

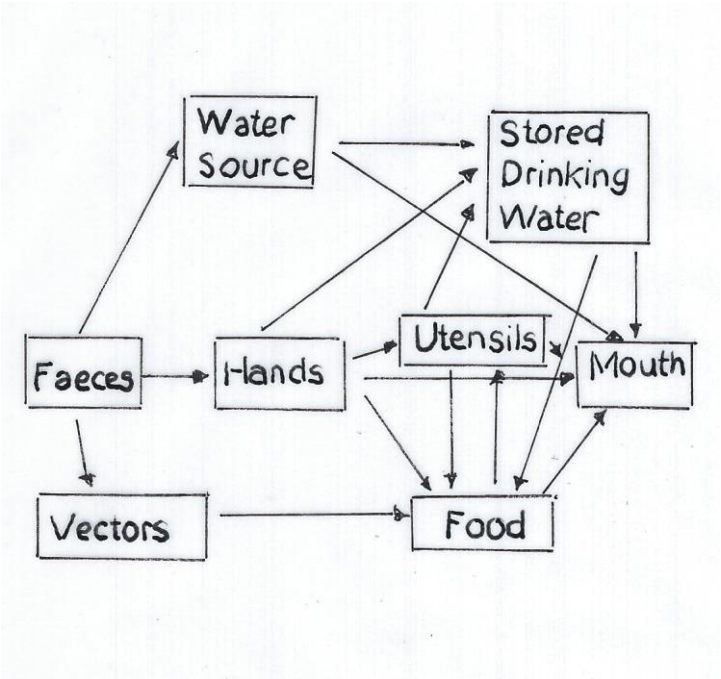

Figure 6.01, provides a simplified illustration of a causal system for enteric disease. Adapted from Johan P. Mackenbach (professor of Public Health), 'Sanitation: Pragmatism works. *BMJ* 2007; 334 doi: 10.1136/bmj.39044.508646.94 (4 January 2007).

The modern studies referred to by Mood are particularly relevant in that they have found variations in enteric diseases associated with different water supplies, even where the water has not been the subject of filtration and chlorination.[8] This is of great value to the 'social epidemiology' study in Chapter 7. A corollary to variations in diseases caused by different water supplies is the manner in which the water was consumed in the study period. Stow refers to different forms of water consumption amongst the rich and poor in early modern London. In his survey of 'The Ward of Farringdon Extra' he describes 'water conveyed in pipes of lead…unto the common weal of the commonalty, to wit, the poor to drink, the rich to dress their meats.'[9] Despite Stow's observations, it is conjecture whether the rich consumed less water directly.

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[8] Ibid.

[9] Stow, *A Survey*, p.360.

Stow's regular reference to the use of lead pipes, however, suggests that consideration must be given to the possible long-term threat to health.[10] Until 1970 it was believed that lead could not enter the water system due to the protection inside the pipes provided by the coating that forms when the surface of the lead oxidises.[11] This was a theory developed in the nineteenth century and was instrumental to installation of lead water mains in housing up to the Second World War. Early modern writers were well aware of the hazards of lead, for example in 1724 there was a reported 'epidemic' in the south-west of England known as 'Devonshire Colic' which was later identified as lead poisoning from cider vats; unfortunately the exact date of this discovery is not given.[12] In the twenty first century the coating of oxide on the inside of lead pipes is no longer considered sufficient protection since the health risks arise from a total long-term build-up of lead in the body from a variety of sources of which lead plumbing may be only one.[13] In 1651 Noah Biggs published *The Vanity of the Craft of Physic* deploring the use of lead for even laboratory equipment used to prepare medicines, let alone the water supply.[14] We saw in Chapter 2 that despite evidence of lead poisoning being presented to the Royal Society in the seventeenth century, further investigations were not pursued, and according to Biggs, pewterers continued to die of 'plombism.'[15]

For those prosperous enough to have water laid-on to their houses, a water lease meant simply a lead cistern, with a stopcock in the kitchen, a yard pump, and perhaps a pipe to an outside 'bog-house', for three or four hours' supply, three days a week.[16] In the city centre there are records of water storage and its location within the

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[10] Ibid., p.171, 'In 1443, John Hatherley, mayor, purchased license of the said king to take up two hundred fother of lead, for the building of water conduits…' Also Peter Morice's lead pipes, p.198; Stow, p.200 re 'the conduit upon Cornhill.'; 282,288, 331;342; 360.

[11] Staveley and Glover, *Surveying Buildings,* p.97.

[12] Dobson, *Contours of Death*, p.427.

[13] Staveley and Glover, *Surveying Buildings,* p.97.

[14] Quoted in Liza Picard, *Restoration London: Everyday life in London 1660-1670* (Phoenix, 1997),p.104.

[15] Ibid.

[16] Weinstein, 'New urban demands', p.39 and Landers, *Death and the Metropolis,* pp. 70-2.

buildings of the pre-Fire period. In some cases there was more than one storage tank; in 1590 a property in Soper Lane, Cheapside was described as having ‘ a lead cistern for conduit water in a lowermost warehouse, and one for rainwater, with two other cisterns.’[17] With regard to the former cistern, this is a rare record of rainwater apparently being collected for domestic use. With regard to the water from a conduit, there are frequent reports of interruption in supplies[18] and reliance on lead storage tanks was therefore likely. This form of storage continued into the post-Fire era [19] and beyond. The use of unsealed cisterns to store water was apparently not considered to be a risk to health. As late as 1821 the superintendent of the London Bridge Waterworks declared that, after Thames water had stood in a cistern for twenty-four hours, it was ‘fine and clear as could be imagined.’[20] It is not possible to determine how much water stored in lead cisterns was used for drinking but Landers appears to consider it in these terms, where he describes this method of storage as compromising its purity.[21] This analysis suggests that purity, in relative terms, would have been a significant issue in middle to upper class housing where cisterns were more widely used.

If a pipe supply was unavailable, not financially feasible or interrupted for many days the needs of a small household could be supplied without too much difficultly by the above-mentioned waterbearers. The Waterbearers’ Company had been incorporated in 1496 and its members walked the streets of London with tall conical containers on their backs holding about three gallons.[22] Picard suggests that the amount which they charged for this service may have varied depending on whether they had simply filled their water vessels from the river or taken relatively

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[17] Keene and Harding, 'St. Pancras Soper Lane 145/38', *Cheapside Gazetteer*.

[18] Weinstein, ‘New urban demands’, p.39.

[19] See Audit D on Amen Court, in the Appendix.

[20] R. Sisley, *The London Water Supply*, p.7, quoted in Gough, *Myddleton*, p.26.

[21] Landers, *Death and the metropolis*, p.71.

[22] Analytical index to the series of records known as Remembrancia:1579-1664 (1878), pp.550-561. URL: http://www.british-history.ac.uk/report.aspx/compid=59994&strquery=water+bearers. Date accessed 22 October 2013.

purer water dispensed by a conduit.[23] There appears to be a lack of documentary evidence regarding Waterbearers taking water from the Thames or any other of London's rivers on a regular basis but that is not to say that such practices did not take place. When the Common Council granted the licence to Peter Morice for the construction of the water-wheel pump under the first arch of London Bridge in 1581, it was stated that it would be of 'no hindrance to the poor water-bearers who would still have as much work as they were able to perform so far as the water of the conduits would satisfy.'[24] A petition presented to the House of Commons in 1600 would suggest that the conduits were the main source of water for the waterbearers. The petition was from 'the whole Company of the poore Water Tankard Bearers of the Cittee of London and the suburbs thereof, they and their families being 4,000 in number.'[25] They complained of illegal diminution of the conduit supplies by private quills.[26]

In 1654 the artisan Nehemiah Wallington provided further evidence of waterbearers taking their supply from conduits. He recorded that the price of a tankard of water had risen from a farthing to twopence on account of the drought in the summer of that year.[27] In this case the waterbearers obtained their supply from a conduit in Cheapside. The drought was so severe that the waterbearers staged a mock funeral by placing 'flowers, bows, and garlands' over the conduit. Wallington recognised the seriousness of the situation, for many of the poor waterbearers were 'likely to be undone for want of work'.[28] It is significant that despite their plight, there is no suggestion that the waterbearers looked to alternative sources of water. The demand for the services of waterbearers began to decline in the late seventeenth century and, if employed at all, the carriers were mainly concerned with the

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[23] Picard, *Elizabeth's London,* pp. 41-42.

[24] Remembrancia:1579-1664 (1878), l.499 pp.550-561. URL

[25] Quoted in Ben Weinreb, Christopher Hibbert, Julia Keay and John Keay, *The London Encyclopedia* (MacMilian, 2008), p.987.

[26] Ibid.

[27]Seaver, *Wallington's World*, p.54.

[28] Ibid.

redistribution of water from the decayed public conduits.[29] This last point is significant in terms of the quality of water from such sources; Mark Jenner has described how public conduits were allowed to decay during the 1680s and 1690s.[30]

Some contemporary accounts may give an idea of the expectations of different water supplies. Dialogues recorded by Claudius Hollyband and Peter Erondell, two Huguenot refuges who taught French for their livelihood in Elizabethan London, provide an account in 1573 where a schoolboy was trying to make preparations for school and attempting to make up for lost time, having got out of bed late. He tells the household servant to bring him some water 'to wash my hands and my face. I will have no river water for it is troubled [muddy]. Give me well or fountain water.'[31] Reference was made in Chapter 4 to the contemporary descriptions of the 'murky quality of the water supplied by the New River' along with the criticism of its poor performance in terms of low pressure which prevented supplies above ground floor level.

The study of wells as another source of water supply focuses on those wells contained within the grounds to a dwelling as opposed to the public wells that were accessed by the comprehensive system of street pumps present in the late sixteenth century.[32] These private wells are referred to as a 'comoditye' in two Viewers' certificates.[33] In the Treswell plans the structure of the well above the ground is always shown made of brick, but these may have been based in some cases on older walls of stone. Treswell shows that wells were located in a variety of positions: a shared well in a yard off Fleet Street;[34] another shared well in the corner of a yard or court in Giltspur Street and Cock Lane;[35] occasionally tucked away between

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[29] Spence, *A Social Atlas*, p.26.

[30] Mark Jenner in a paper 'Networks of water in London: 1500-1725' delivered to the Metropolitan History seminar, Institute of Historical Research, 1994, quoted in Spence *A Social Atlas*, p.26.

[31] M St. Clare Byrne (ed.) *The Elizabethan Home, Discovered in Two Dialogues by Claudius Hollyband and Peter Erondell*, (London, 1949), p.2.

[32] Schofield, *London Surveys of Ralph Treswell*, p.27.

[33] *London Viewers*, 290 [C.85] 31 December 1550 and 398. [C.193] 2 August 1558.

[34] Treswell, *London Surveys*, p.81.

[35] Ibid. p.86.

buildings, with only one side available for access, such as in Dudley Court, Silver Street;[36] and in several cases lying astride a boundary between two properties, for example 16 Cornhill.[37] A property in St Martin Pomary, Cheapside was described in 1570 'as a messuage with wells,' but the number is not specified.[38]

As the role of the Viewers was to resolve a dispute between neighbours there is more evidence of defects with shared or 'party' wells. The disputes relate to a lack of maintenance and by implication, potential contamination. In 1550, in the parish St. Sepulchre without Newgate, the Viewers inspected 'a messuage and certain tenements which [were] decayed.'[39] Included on the plot was 'a party well in decay, which the two tenements ought to repair and mend.'[40] Eight years later the Viewers were asked to settle 'a varyance in the parishe of our blessed lady at Bowe in Hosyer lane' in St. Mary le Bow and they determined that 'the [*partie*] plaintyff ought of right to have suche parte Comoditye, use, and occupacion of a well there Betwene the groundes of the said [*parties*] as he now hath.'[41] Having established joint ownership of the well, the plaintiff was to ' repayre as well the one half of the said well as to repayre and amend all the said Brykwall.'[42]

According to Ernest Sabine, wells were an important source of water supply until the 1870s but in his view they were being corrupted by the close proximity of cesspits.[43] This will be looked at in more detail in the next section of this Chapter but as noted in Chapter 4 the Assize of Building did attempt to control the location of cesspits relative to boundaries. There was more evidence, however, that the users were aware of contamination through the depositing of waste directly into a well or through the growth of vegetation. A workman in St. Botolph without Aldgate was

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[36] Ibid., p.113.

[37] See Audit B in Appendix.

[38] Keene and Harding, 'St. Martin Pomary 95/18', *Cheapside gazetteer* Date Accessed: 14 October 2012.

[39] *London Viewers*, 290 [C.85] 31 December 1550.

[40] Ibid.

[41] Ibid., 398. [C.193] 2 August 1558.

[42] Ibid.

[43] Sabine, 'Latrines and cesspools' p.318.

asphyxiated when attempting to clear rotten vegetation out of a well. The account of this accidental death tells how 'Henrye White A pumpmaker… was smothered by the damp of a well'.[44] This death occurred in 1584 and Forbes considers that it is likely that 'damp' (in this sense a now, obsolete term for gases such as carbon dioxide and methane that may accumulate in coal mines) had been produced by rotting vegetation near the water and had collected in the well.[45]

The disposal of waste and artefacts into wells has been recorded in archaeological reports. Wells excavated in 2000 in Paternoster Square, and Paternoster Row, EC4 revealed 'brick-lined wells and these produced a few artefacts, including two bone medical syringes, pottery, and bottles.'[46] The disposal of large quantities of refuse into disused wells has in some cases made it difficult to distinguish them from disused refuse pits and cesspits.[47] It is not certain if this pollution of the wells took place during their use or long after they had dried-up but the tragic account of Henrye White suggests that abuse of this source of water supply may have occurred. The terms "Flux," "scouring," or "bloody flux" referred to in the Bills of Mortality in most cases probably indicated dysentery. The contamination of water would be expected to make this a common type of disease, particularly in the warm months. Having considered the 'function' and 'performance' of various water supplies in the *building pathology* sense, the 'social epidemiology' is discussed in Chapter 7.

6.2 The removal of excrement from the buildings

As noted in Chapter 4, there was no mains foul water drainage in early modern London. A study of documentation relating to pre-Fire buildings reveals that the majority of foul water drainage was in the form of a privy comprising three components: the seat or 'stool', usually built over timber joists; the garderobe chute, often lined with boards, lead or brick, which was called a 'pipe', or 'tunnel' or

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[44] Forbes, *Chronicle from Aldgate*, p.150.

[45] Ibid.

[46] MoL NGT00.

[47] Ibid. FHC00 56-59 Fenchurch Street, 18 London Street & 76 Mark Lane EC3.

'funnel',[48] and lastly, a cesspit sometimes described as a 'vault'. Privies are also described in numerous Viewers' certificates as a 'jakes', 'draught house' 'siege' or 'sege' or 'withdraught'.[49] The Viewers frequently use these terms in specifying general repairs to privies, without necessarily referring to the stools, chutes and vaults. A Viewers' certificate of 1550, provides a relatively rare example of the description of essential repairs to some of the components to a privy in a house in Knightrider Street, in the parish of St. Mary Magdalen:

> The viewers say that Ellys [one of the parties to the dispute] has taken down a tunnel of boards for a jakes which went through his kitchen, having fall down into a cistern in the ground there. He ought of right to make it up again at his own proper costs and charges; and when need requires, the cistern shall be made clean by every man having his jakes falling into the same vault in the house of William Hollingworth, otherwise called Snowden [the other party in the dispute].[50]

The 'function' of a cesspit in the early modern period was, as it is today, to retain the soil and waste material until it was emptied. The 'night soil men' would be expected to undertake such a service and this is considered below. Archaeological reports suggest that the 'function' of privies was not only to collect excrement and urine but also general waste, particularly from kitchens. The reports have revealed that larger pieces of food waste and kitchen utensils are often found in cesspits on archaeological sites in the city.[51] The location of privies shown in Treswell's plans would tend to confirm this, where in many cases in the city centre the ground floor privy could be found within or adjacent to the kitchen block. In other instances the privy was part of the structure, but entered by a separate door from the yard;[52] the privy was also occasionally approached through the kitchen.[53] The Viewers described the close proximity of the privy to the kitchen in the above case in Knightrider Street

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[48] For example, see *London Viewers*,16 [B.11]5 December 1511.

[49] This is confirmed by Loengard in the Glossary, *London Viewers*, pp.163-4.

[50] Ibid. 288 [C.83] 25 November 1550.

[51] For example MoL NGT00 Paternoster Square, Area 4 and Paternoster Row EC4 Schofield; QVR00 Walker House, 87 – 95 Queen Victoria Street EC4 and observed by Schofield in *The London Surveys of Treswell*, p.20.

[52] Treswell, *The London Surveys*, p101; see Foxe's Court [St.] Nichlas Lane, 23-5 Abchurch Street.

[53] Ibid, 115 and 118 Fenchurch Street, 12-14 Billiter Street, p.76.

and in 1551, they recorded 'a kitchen over a certain party jakes' in a dwelling occupied by a John Tocke, in St Swithens' Lane in the parish of St. Swithen.[54]

Thus, although these proximities of privies to kitchens aided, and were perhaps intended for, the disposal of food waste from the kitchens, it would have also provided a significant pathway for airborne disease spread by flies. As noted in Chapter 4, vectors such as the common housefly, *Musca domestica* have been shown to be responsible for the transmission of human diseases during epidemics. This could be seen as a failure in the 'function' of privies but other shortcomings may be identified through examining their 'performance'. As noted in Chapter 5, ten per cent of building defects recorded in the Viewers' certificates were related to defective privies.[55] In their surveys of historic buildings in England, Watt and Swallow have listed the five most common failures in the 'performance' of cesspits: defects to brick walls of the pit; failure of impervious finish to internal walls, causing leakage; inadequate capacity for foul-water load; inadequate access for emptying; presence of outlets, such as an overflow pipe into a ditch or onto neighbouring land; an absence or failure of seals allowing escape of noxious gases.[56] These are now considered in the early modern context.

With regard to defects in the walls of the cesspit, the Viewers' reports contain many references to defects in the stone and brick structures. The discovery of the defects often followed the complaint of 'a noisome jake' or 'withdraught' and also addressing a dispute between neighbours over the liability for repairs and use. In 1546, in the parish of St. Peter the Poor, the Viewers discovered two jakes which had 'an old stone wall between them falling down.' [57] The Viewers stated that 'The old wall ought of right [to be] new made 2 ft. thick and set in the same place that it now stands in . . . at costs and charges of both parties ... and that the parties . . . cleanse and carry away the ordure or dung.'[58] The poor performance of stone, and to a lesser

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[54] *London Viewers*, 295 [C.90] 13 March 1551

[55] See Chapter 5, figure 5.01.

[56] Watt and Swallow, *Surveying Historic Buildings*, p.182.

[57] *London Viewers*, 202[B.196] 1 September 1546.

[58] Ibid.

degree brick, in damp conditions was discussed in the last Chapter but the archaeological evidence confirms that builders did not have any options in using alternative materials below ground level.[59]

As previously stated, there is a lack of documentary evidence on the building of cesspits following the Great Fire. The Rebuilding Act of 1667 did, however, refer to surface water drainage systems or 'sewers' and 'Vaults' and in the schedule or 'scheme' to the statute, where the 'side walls' of the vaults were to be built one brick thick and the 'Bottome paved plaine and then 1 bricke and edge circular.'[60] There is a possibility that cesspits were rebuilt to similar specification. In Paternoster Square, and Paternoster Row EC4, an archaeological report has recorded that there was a large square brick built cesspit, constructed over an earlier pit made of greensand and chalk blocks.[61]

With regard to the second most common defect noted in cesspits in historic buildings, the study of failures in the impervious finishes is problematic. Documentary evidence has not revealed the use or recognition of such a material. Thus, there would appear to have been a strong possibility of seepage of the contents into the surrounding soil. There are reports, however, of cesspits overflowing suggesting that the walls were remaining relatively impervious; alternatively, the reason for the cesspit overflowing was possibly due to the saturation of the surrounding subsoil.[62] The poor natural drainage quality of London Clay subsoil, such as that to the exposed outer rim of the city's geological basin,[63] would be more prone to saturation by leaking cesspits; the only path for the foul-water was above and over the clogged pores to the clay soil.

The mixture of clays, sand and gravel from glacial and river depoits towards the city centre and river-front would have been conducive to better drainage, but as a

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[59] Brick lined cesspits are recorded in many reports, for example BII00, 5 Billiter Street EC3 and NGT00, Paternoster Square, Area 4 and Paternoster Row EC4.

[60] An Act for rebuilding the Citty of London ', pp. 603-612. Date accessed: 14 October 2012.

[61] MoL NGT00.

[62] Watt and Swallow, *Surveying Historic Buildings*, p.182

[63] Archaeological reports have recorded pockets of London Clay near the city centre in Middle Temple Lane EC4, MoL MTN00.

result there was a greater risk of the contents of the cesspit soaking into the ground and contaminating subterranean water courses.[64] The contamination of wells was a particular risk when positioned close to a cesspit as in the case illustrated in Treswell's survey of Smith's almshouse, St Peter's Hill (see Figure 6.02 below).[65]

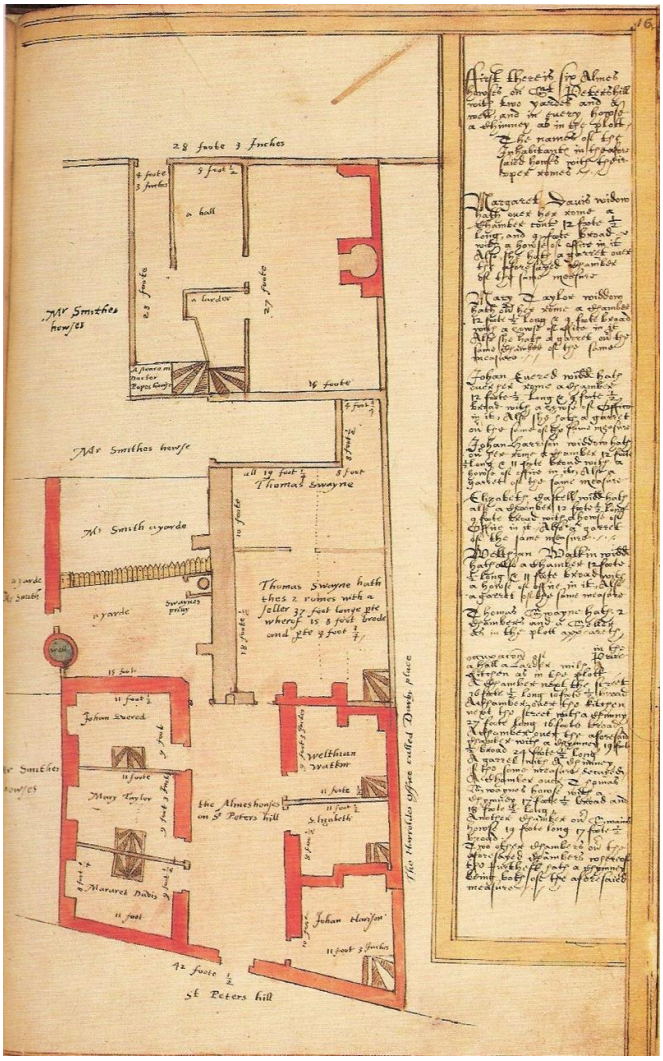

Figure 6.02. Smith's almshouses, St Peter's Hill, 1611.

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[64] Archaeological reports on the city centre frequently refer to the natural geology on the various sites consisting of brickearth (clay) overlying banded sands and gravels. For example see BII00 5 Billiter Street EC3 and NGT00 and Paternoster Square, Area 4 and Paternoster Row EC4. In the case of the Mercers Hall, Ironmonger Lane EC2, the report (sitecode POY00) recorded natural sand and gravel was encountered at between 8.98 and 9.93m, whereas excavations in St Paul's Churchyard (sitecode SLY00) and 56-59 Fenchurch Street, 18 London Street & 76 Mark Lane EC3 (sitecode FHC00) revealed gravel terraces.

[65] Ralph Treswell, *London Surveys*, Plan 8.

In this example David Mith's well, which is shown as the circular feature to the middle left-hand side of the plan, is only some twenty feet from Thomas Swayne's privy (to the centre of the plan). Contamination of this particular well would not only affect Mith's household but also the neighbours who shared this facility.

A report produced in 1866 by the Commissioners for Sewers suggests that the cool sparking waters of these wells were preferred by people to the pipe water of the two city companies. According to this report, however, the very sparkle of these waters was due to the presence of ammonia and other organic matter in solution. The Commissioners concluded the cause of such contamination was the frequent pollution of wells by 'privy filth.'[66] Sabine considers that such contamination was likely in the medieval period and became more of an issue into the early modern period with a greater number of cesspits being excavated as legislation, local acts and public objections prohibited the discharge of excrement into rivers, drains and water courses.[67]

Modern Building Regulations stipulate that a cesspit should be sited 15 metres from a dwelling.[68] It is clear that the sixteenth-century Viewers were not enforcing the medieval regulations identified in Chapter 4, which stated the minimum distances of cesspits from neighbouring properties. It has already been noted that some privies were located within buildings, and a view in 1551 provides another example, concerning an internal 'party jakes' situated beneath the kitchen in a house in St. Swithin's Lane near Lombard Street.[69] The Viewers did not discourage this practice but stated merely that it was to be maintained and cleaned by both the plaintiff and defendant.[70] Poor practices continued into the eighteenth century where Summerson observes that in the larger houses of the better off, sanitary accommodation consisted of a spacious 'bog house' built at the end of the garden or attached to the back of the

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[66] Quoted in Sabine, 'Latrines and cesspools', p. 318.

[67] Ibid.

[68] F. Hall and R. Greeno, *Building Services*, p.249.

[69] As already noted, Viewers often used the term 'jakes' to describe the stool, chute and vault.

[70] *London Viewers* 295 [C.90] Mar.13 1551.

house; a brick lined circular pit was constructed under it. Elsewhere and particularly in the tenements, the privies were often located indoors at the foot of the stairs, but the major sanitary problem was that of disposal.[71]

The regular overflowing of cesspits may also be related to the third defect noted by Watt and Swallow, the inadequate capacity for foul-water load. Samuel Pepys raised the question of the capacity of a cesspit when he had the unfortunate experience of stepping into his cellar one day and putting his foot 'into a great heap of turds, by which I find that Mr Turner's [his neighbour] house of office is full and comes into my cellar.'[72] Pepys invited Mr Turner 'to see where his vault for turds may be made bigger, or another made for him.'[73] The modern Building Regulations require a minimum capacity below inlet level of 18,000 litres. The capacity is based on 150 litres per person per day at 45 day emptying cycles, for example, a four person house: 4 x 150 x 45 = 27,000 litres (27 cubic metres).[74] Schofield has recorded a pit measuring 10 feet by 12 feet in plan and 10 feet deep in Godliman Street, in the city centre, which he considers to be large in relative terms.[75] This cesspit had a capacity of 1200 square feet, or 33.98 cubic metres, clearly larger than the modern example required for four persons. Applying the above formula for calculating the appropriate capacity for an early modern cesspit is problematic for many reasons.

The average household size in Cheapside has been estimated as 6.6 persons.[76] Even if we enter this figure into the formula to calculate the size of a cesspit to service an average city centre household, there is difficulty in assuming that each person would produce 150 litres of waste per day. This figure has been estimated in the modern context, and would include a person utilising piped water and contributing to using the appliances in the baths and kitchen. The World Health Organisation has made studies in undeveloped villages in Africa, where they have

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[71] Summerson, *Georgian London*, p.82.

[72] *The Diary of Samuel Pepys*, 20 October 1660.

[73] Ibid.

[74] Hall and Greeno, *Building Services*, p.249.

[75] Schofield, *Medieval London Houses*, p.87.

[76] Harding *et al*, *People in Place*, p.14.

designed water-borne sanitation systems based on removing 1-1.5 litres of human excreta per person per day (urine makes up 90% of the volume of excreta).[77] Although it could be argued that the demands on early modern cesspits was not as great as those in the twenty first century, consideration must be given to the way they were often used. As already noted, there is evidence of the disposal of kitchen waste into the privies and this would have made other demands on the performance of an early modern cesspit. There are also a significant number of Viewers' certificates confirming that more than one dwelling often used a common cesspit.

The Viewers often described such cesspits as 'partible' and they would determine the apportionment of costs when it came to cleaning out the chamber. Following the construction of a new property in the parish of St. Nicholas Acon in 1552, the Viewers considered the impact of connecting new privies to an existing cesspit, utilised by a neighbouring house. The Viewers directed 'The parties ought to make clean their cistern or jakes there when need shall require in manner and form following: that is to say, the party with more tunnels or stools falling into the same to bear charges after that rate indifferently.'[78] Similar arrangements were specified in the lease of a large property in St. Mary le Bow in Cheapside.[79]

Most of the houses surveyed by Treswell had at least one privy. The Viewers provide examples where the number of privies was increased within individual dwellings. In 1542 in the parish of St. Dionis the Viewers inspected a 'certain noisome withdraught' where the head of the household, a John Dymok had 'three stools: one for his own chamber, another for his maidens' chamber, and the third for his menservants' chamber.'[80] London houses, like those in towns elsewhere, had privies on the first and upper floors. At 21-22 Trinity Lane the tenancy included a first-floor room 'with a funnel of a privy out of the room above' and the plan of the

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[77] http://www.who.int/water_sanitation_health/sanitproblems/en/index1.html: accessed 23 October 2013.

[78] *London Viewers* 323 [C.118] 1 September 1552.

[79] Keene and Harding, 'St Mary le Bow',104/11, *Cheapside Gazetteer*.

[80] *London Viewers* 170 [B. 165] 15 July 1542.

adjacent tenancy shows two funnels going down the back of his ground-floor privy, presumably to a common cesspit.[81]

The disruption and expense of emptying cesspits may have been a factor in delaying the task, which included breaking into the masonry of the pit to clean out the chamber, and then a bricklayer and carpenter would be required to rebuild the top and relay the joists. The above formula for designing the capacity of a cesspit assumes that the chamber would be emptied every 45 days; this also creates problems in the application of this formula into early modern London. From surviving accounts it is difficult to judge how long the intervals between cleaning of cesspits were in early modern London; this task was normally undertaken by labourers or special contractors called 'gongfermers' [82] The Viewers did not attempt to calculate intervals between cleaning and typically certified that 'the parties ought of right to clean the cistern of the jakes as often as need shall require at equal costs and charges.'[83] Even references to lease covenants pertaining to city centre properties lacked specific directions on cleaning. For example, a John Cornelis, a goldsmith, acquired a new lease in 1591 of a property known as the Rose, in St Mary Colechurch, where he was 'to repair and cleanse the 'privyes, sinckes, and seiges' at his own cost…'[84]

As the density of building in the pre-Fire city centre increased, this presented a problem for access for cleaning out cess pits, particularly when larger houses were converted; this is the fourth possible defect identified earlier. Sometimes the vault was broken into from vacant ground if it was beside or between houses or from within one of the houses it served. In one extreme case a Henry Dolfyn, a neighbour of the above- mentioned John Dymok had to endure 'no lesse then xxx tonne' of excrement being transported through his house in order to clean out the cesspit. To gain access to the cesspit, the Viewers directed that 'the wall of the withdraught to be broken within the warehouse of Dolfyn.' The removal of 30 tons of excrement would suggest a large cesspit, which the Viewers considered would not require 'a clene for

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[81] Treswell, *London Surveys,* p.126

[82] Ibid.

[83] *London Viewers,* 320. [C. 115] 22 June 1552.

[84] Keene and Harding, 'St. Mary Colechurch 105/22', *Cheapside Gazetteer* pp. 540-549.

many yeres to come.'[85] No further details are provided on how they arrived at this decision but it would seem that there was no early modern formula for calculating the foul-water load in the design of cesspits. Due to the various uses to which these cesspits were used, it has also not been possible to apply a modern formula. If the cesspits were not appropriately designed, or emptied at regular intervals then consideration is given to the next defect identified that is, the presence of outlets, such as overflow pipes into a ditch or onto neighbouring land.

There would not appear to be any evidence of reports that users of privies deliberately punctured holes into the walls of the cesspit to allow the liquid contents to flow out and thereby reduce the amount of times the vault needed emptying. This is not to say, however, that such practices were beyond the actions of an unscrupulous user of a building. The escape of excrement onto neighbouring land was more often the result of neglect, or poor design. The privy chute, however, did not always communicate with a pit. Schofield has described medieval privies along the waterfront of the Thames and being built over the Walbrook and other streams.[86] Treswell's survey in 1611 of 1-6 Fleet Lane shows privies over the Fleet River.[87]

The final defect to consider is the absence or failure of seals allowing escape of noxious gases. The modern cesspit has a sealed cover and is connected to the water closet by clay or plastic pipes, which would include a water-filled interceptor trap to prevent the escape of noxious gases and limit access from the cesspit into the house by flies and rats. Water-filled traps were not invented during the study period but as we have seen, the chute connected the stool to the pit. The size of the early modern chutes were often specified by the Viewers, for example in a house in the parish of St. Nicholas Olave 'the tunnel of the jakes' was measured as being '21 in. in breadth.'[88] Typically the chutes were between 1 and 2 feet wide, sometimes cut into the masonry of an adjacent wall.[89] There was clearly a significant pathway for flies and rats from

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[85] *London Viewers*, 170 [B. 165] 15 July 1542.

[86] Schofield, *Medieval London Houses*, p.87.

[87] Treswell, *The London Surveys*, p.81.

[88] *London Viewers*, 320 [C. 115] 22 June 1552.

[89] Ibid., 270 [C.65] 11 March 1550.

the cesspit into the house. The Viewers often use the term ‘fall’ or ‘falling’ of jakes, stools and tunnels[90] but this may be a descriptive term, referring to the discharge of the contents of privy, rather than specifying the laying of the chutes at an angle for drainage purposes. If there was an insufficient slope to the chute, the sides of the structure would have become contaminated with filth, but the cleaning of ‘tunnels’, ‘pipes’ and ‘funnels’ is rarely mentioned unless the Viewers considered it as part of the general cleaning of the privies.

Thus, there are a large number of Viewer reports confirming that the five most common defects noted in historic buildings surveyed in the modern era existed in this study period; this had the potential to be a major source in the spread of pathogens in houses of all social groups. As noted in Chapter 4, basic to the prevention of enteric disease and morbidity from diarrhoeal disease is the provision in all dwellings of a safe, sanitary means for the disposal of human excreta. Indoor, private flush toilets with sanitary means for the disposal of the sewage seem to be by far the best measure.[91] Toilets or water closets, as we know them, were first seen in the designs of Sir John Harrington in 1596, godson to Queen Elizabeth I. The water closet, for the most part, worked, and the Queen had Sir John installed a water closet in the Royal Palace. One of the many problems with Sir John’s water closet was that it was inadequately vented and sealed, and sewer gas constantly leaked into the Royal powder room. The Queen’s household remedied this problem by placing bowls of herbs and fragrances around the room. The flush toilet, however, would not be deemed popular for several hundred years and did not appear in any number until the nineteenth century.[92]

The relationship between the means available for the disposal of human excreta and the prevalence of enteric disease was only fully recognised as an important health measure from 1875.[93] While the facilities for the disposal of

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[90] Ibid., 320 [C. 115] 22 June 1552; 323 [C.118] 1 September 1552; 333 [C.128] 14 December 1552.
[91] Mood, ‘Fundamentals of Healthful Housing’, p. 308.

[92] Watt and Swallow, *Historic Buildings*, p.180; Marshal and Worthing, *The Construction of Houses*, p.277.

[93] This led to legislation such as the 1875 Public Health Act, see Knowles and Pitt, *The History of Building Regulation in London*, p. 82.

excrement were universal, and therefore universally problematic, it was the growth of London's population and intensification of settlement that made it much worse, keeping humans and their excrement in close proximity, and exposing them to infection from neighbouring sources as well as their own. The absence of any Viewers' certificates relating to the provision of and repairs to cesspits and a privies in the post-Fire era is striking. Neither proclamations nor statutes appear to address this shortfall and yet this coincides with the reduction of enteric diseases.[94]

6.3 The indoor environment

The indoor environment embodies those aspects that *building pathology* refers to as the 'hygrothermal environment', which is the movement of heat and moisture through buildings.[95] Those aspects such as heating, lighting and ventilation will influence requirements for comfort, health and safety. Interactions occur between the physical elements of the environment such that each component has to be critically considered in relation to the effects on others, and this is particularly relevant when devising housing standards in the modern era. For example, enlarging the window area with the intention of improving natural lighting can result in overheating by increasing thermal gain from solar radiation and conversely there will be greater heat loss from the internal environment in cold external conditions.[96] It was noted in Chapter 4 that the increase in the demand for housing in early modern London's city centre led to the upward extension of buildings; consideration will be given to whether this led to an increase in the number and size of windows, compromising the thermal stability.

Another common example of interaction between the physical elements of the environment in the modern context is the effect that thermal insulation of a building by draught-proofing can have in reducing ventilation and affecting air quality; in the early modern context this would be the hanging of heavy fabrics and curtains in front of windows, or blocking-up such openings. This section of the Chapter will investigate early modern expectations, and possible trade-offs made between such competing demands, and consider the health implications. A satisfactory indoor

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[94] Harding, 'Housing and Health', p.31.

[95] Collins, 'Cold and heat related illnesses', p.117.

[96] Ibid.

climate also has a bearing on home safety. Although accidents are not the focus of this thesis, it is important to recognise that some accidents are less likely to occur in well-lit, thermally comfortable surroundings.

6.3.i Heat loss from buildings

It was noted in Chapter 4 that of the many important aspects of healthful housing, probably none is more important in the temperate climate zone than the need to provide and maintain a warm environment within a dwelling to meet physiological requirements, particularly for the young, old and those who are already ill.[97] Heat is lost from the interior of a building to the exterior and the lower the outside temperature, the greater the heat loss will be. Consideration is given in this section of the Chapter to the thermal insulation qualities of London's early modern buildings as determined by differences between external and internal temperatures.

According to Thomas Markus, the severity of the climate fully explains the variations in heat loss between two identical houses, used in a similar manner and heated to the same standard. It is usually external air temperature that is used as a measure of climate.[98] The index used is normally the 'Degree Day'. This is a useful modern concept to engage in the early modern context as it is based on the finding that an unheated house maintains an internal temperature several degrees above that of the outside as a consequence of activities by the users, shelter from wind and the heat gains from solar radiation through windows (even from overcast skies). The exact difference in temperature depends on the specifics of all those variables but is often of the order of 3 degrees centigrade (degC). This means that if, for instance, an internal temperature of 20 degC is to be attained, the house will not require heating until the external air temperature drops to 17 degC or below; this is known as the 'base temperature'. If the average external temperature drops for one day by 1 degC below this base, this is known as 'one Degree Day'; if it drops by 2 degC for one day, or by 1 degC for two days, this is known as 'two Degree Days' and so on.

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[97] Mood, 'Fundamentals of Healthful Housing', p.326.

[98] For this and what follows in this section of the Chapter see Thomas Markus, 'Cold, Condensation and Housing Poverty'pp.154-7.

The severity of the climate with regard to heat loss is greater than Degree Days indicate, however, since they exclude the effect of wind, sunshine and rain, all of which will affect heat loss. Rain, by wetting porous external walls, will reduce the fabric's insulation values. Recent research has shown that damp walls allow 38% more heat loss than an equivalent dry wall.[99] A vicious circle between other forms of damp and condensation can thus be set up.[100] As already noted, the use of wainscot and other linings to better quality housing may have reduced draughts, but heat would be conducted through the material, particularly if the external fabric was damp. Wind will determine the rate at which leakage of air between inside and outside takes place. Even in a modern insulated house, heat loss resulting from such leakage could be over half the total heat loss. It is not possible to forecast accurately the safe temperature limits for health, for there are wide individual variations[101] but in the modern era 15.5 degC is often taken as the base for the UK but Markus has acknowledged that some have argued it should be as low as 12 degC.[102] On the basis that the requirements of the human physiology have not changed significantly since the early modern period, it would be reasonable to assume similar base temperatures. Consideration must now be given to the likely temperature ranges experienced throughout the study period.

As the sixteenth century wore on summers were short and wet and winters were savage.[103] Margaret Spufford has referred to a 'sharp cooling period' in the late sixteenth and seventeenth centuries across western Europe and in every decade from the 1530s onwards, there were at least two winters, sometimes three, which were recorded as 'severe', 'very severe' or 'extremely severe.'[104] Similar qualitative, rather than quantitative, terms have been used by Dobson in plotting seasonal weather

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[99] Catherine Bull and John Edwards, 'The writing on the wall', *Building Surveying Journal* (RICS, December 2011), p.6.

[100] Markus,'Cold, condensation and housing poverty', p.144.

[101] Collins 'Cold and heat- related illnesses', p.118.

[102] Ibid.

[103] Picard, *Elizabeth's London,* p.242.

[104] Margaret Spufford, 'Chimneys, Wood and Coal' in P.S. Barnwell and Malcolm Airs, *Houses and the Hearth Tax* (The Council for British Archaeology, 2006) p.22.

conditions across the south-east of England in the early seventeenth century. For example, in the years 1601-1629 and in 1614 and 1624 the spring seasons were classified as 'very cold', whereas the summers of 1608, 1618 and 1627 were 'cool', and described as 'cold' in 1621 and 1626. The winters of 1607, 1614, 1615 and 1621 were 'severely cold.'[105] The importance of the nexus between cold and damp conditions in housing has already been emphasised and it is therefore of value to note that the summers of 1608,1621,1625 and 1626 were classified as 'wet'; 'very wet' weather was experienced throughout the year of 1617. It is the years 1625 and 1626, however, that stand out in terms of being consistently 'damp' and 'severely cold'.[106]

These weather conditions are possibly best explained by the climate of the period. The period between 1300 and 1870 has been described as the 'Little Ice-Age' during which Europe and North America were subjected to much colder winters than experienced in the modern era. The period between 1600 and 1800 marks the height of the 'Little Ice-Age.'[107] John Evelyn recorded in his diary on the 27th December 1683 'It being in England this year one of the severest frost that has happened for many years'.[108] By 6th January 1684 the Thames was 'quite frozen' to the extent booths were 'planted in formal streets' on the thick ice and filled with 'all sorts of trades and shops furnished, and full of commodities'.[109] By the end of the month 'the frost was continuing more and more severe' that trees not only splitting as if lightening struck, but men and cattle perishing in divers places.'[110] With the exceptionally low temperatures came other problems in terms of obtaining fuel for fires, and this lead to 'great contributions [being] made to preserve the poor alive'.[111]

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[105] Despite this qualitative assessment, Dodson draws on a number of reliable sources and these are given in her book *Contours of Death*, p.371.

[106] Ibid.

[107] Lamb H.H., 'Climatic Fluctuations', in H. Flohn (ed), *World Survey of Climatology. Vol.2. General Climatology* (New York: Elsevier, 1969), p. 236.Lamb is one of Dobson's sources.

[108] *The Diary of John Evelyn*, Volume II, William Bray (ed.) J.M. Dent, London, 1946, and 6th January 1684, p.195.

[109] Ibid., p.196.

[110] Ibid., pp.196-7.

[111] Ibid., p.197.

Evelyn observed that 'Nor was this severe weather much less intense in most parts of Europe' but Londoners had additional problems, particularly those already ailing from respiratory illness 'by reason of the excessive coldness of the air hindering the ascent of smoke, was so filled with the fuliginous steam of sea-coal […] this filling the lungs with its gross particles, exceedingly obstructed the breast, so one could scarcely breathe.'[112] The thaw set in during the middle of February that year, followed by torrential rain and yet the Thames remained frozen.[113]

Waller has reflected on thermal conditions within the house at the turn of the seventeenth and eighteenth centuries: 'even with a coal fire in the parlour, the bedrooms and the kitchen, it is hard to imagine just how bitterly cold a London house would have felt for a large part of the year, especially as winters in the late seventeenth century were considerably colder than they are now.'[114] The performance of open fires is considered in the next sub-section to this Chapter, but this part of the thesis is focusing on the rate of heat loss through the building fabric. *Building pathology* uses heat-loss calculations to estimate the rate of heat loss from buildings. In the modern era heating engineers can apply heat loss calculations to design a heating system for existing as well as new buildings.[115] The 'thermal transmittance' of a building element, together with the resistance of its two surfaces, will determine the rate at which heat flows from the warmer to the colder side. The reciprocal of this is known as the 'thermal transmittance', or U-value through an element, formally defined as: 'the heat flowing through an element, measured in watts per square metre of surface area, per degC difference between the inside and outside temperatures.'[116] From the research into the construction types referred to in this Chapter, heat loss calculations have been produced and are summarised in the Building Audits in the Appendix to this thesis.

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[112] Ibid.

[113] Ibid., p.198.

[114] Waller, *1700*, pp.140-1.

[115] Hall and Greeno, *Building Services*, pp.123-5.

[116] Thomas Markus, 'Cold, condensation and Housing Poverty' p.144.

In terms of thermal comfort, timber-framed buildings are inferior to brick. The majority of the heat would have been lost through the wattle and daub. The lining of the interior of the walls with heavy fabrics and wainscot boarding may have reduced draughts but the loss of heat through thermal conduction would still have been relatively high. It was noted earlier that new buildings were constructed in cavity walls after 1938 as they provided better resistance to damp penetration than solid walls; they also have superior thermal insulation qualities.[117] Writing in 1703, R. Neve noted the poor insulation performance of solid brick walls in terms of heat gain and loss: 'The greatest objection against London houses (being for the most part brick) … if there happens to be a long fit of excessive heat in the summer, or cold in the winter, the walls being thin, become at last so penetrated with the air that the tenant must needs be uneasie in it…'[118]

Comparisons of the Audits in the Appendix show that brick walls would have performed better than the timber-framed house but recent research has shown that the difference is not significant.[119] Thus, heat loss from all buildings, of all social classes, over time, would have been high in the context of the extreme climatic conditions experienced during the study period; the indices used in the Building Audits show that heat loss would have been high even during relatively milder conditions. This is significant in the early modern context because as noted in Chapter 2, the middling sort and wealthier members would have been mainly confined to the home during illness rather than a hospital. Amongst other matters, the next Chapter will consider whether the provision of fireplaces within the dwellings compensated for the inherently poor insulation qualities of the building fabric. This can only be assessed, however, after considering the performance of open fires.

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[117] Staveley and Glover, *Surveying Buildings*, p.185.

[118] Quoted in Cruickshank and Wyld, *Georgian Building*, p.3.

[119] Caroline Rye and Cameron Scott, *The SPAB Research Report 1: U- Vale Report 2012*, http://www.spab.org.uk/downloads/SPABU-valueReport.Nov2012.v2.pdf.

6.3.ii Inefficient open fires

The importance in a temperate climate zone of providing and maintaining a thermal microclimate within a dwelling to meet the physiological requirements of the occupants would appear to be a given. As noted in Chapter 4, a similar point was in 1779 by Robert Clavering.[120] This would not have been a 'user requirement' peculiar to the occupants of London's early modern buildings but consideration of the potential to heat the dwellings is required in analysing building-related illnesses across all social groups in the capital.

It has been noted in Chapter 4 that numerous studies of housing in the modern era have concluded that adequate warmth in the home is necessary for the health and comfort of the occupants and to ensure that condensation and mould growth do not occur.[121] Despite this awareness of a potential source of building-related illness, there is no requirement in building or environmental health regulations that a home in the twenty first century should contain a central heating system. Dr Brenda Boardman considers this is one reason why British homes are difficult and expensive to heat and the likelihood of having adequate, 'affordable warmth' is a remote possibility for many households. [122] Boardman concludes that 'as a result, thousands of people will continue to suffer from discomfort in their own homes and from cold-related illness and death.'[123] It was estimated in 1991 that 6.6 million households were suffering from 'fuel poverty' because of the energy inefficiency of their homes. Boardman has observed that Britain has a particularly poor record on excess winter deaths with a rate that is greater than in countries with similar or colder climates.[124] Homes that are expensive to keep warm are energy inefficient for they are generally deficient on

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[120] Clavering, *An Essay*,p.13.

[121] Burridge and Ormandy, *Unhealthy Housing*, Chapters 6 and 7.

[122] Brenda Boardman, 'Prospects for Affordable Warmth' in Burridge and Ormandy, *Unhealthy Housing*, p.382. When this account was written Boardman was a Senior Research Fellow at St Hilda's College, Oxford; she is the author of *Fuel Poverty: From Cold Homes to Affordable Warmth*, (Belhaven, London, 1991).

[123] Ibid.

[124] Ibid. p.385.

three fronts: inadequate thermal insulation, inefficient heating systems and reliance on expensive fuels. The measurement of the energy efficiency of the home is vital if there is to be any certainty that a household, having regard to its income, can achieve 'affordable warmth.'[125]

In applying these three factors pertaining to energy efficiency in early modern London's buildings, the first factor relating to thermal insulation has already been considered in detail in this Chapter. The rate at which heat would have been lost through the fabric of timber and masonry buildings has been compared. Although the building proclamations extolled the superior quality of brick-built houses over the older timber-framed dwellings, in January 1666 Pepys experienced how cold a brick house could become. While staying as a guest in a house in Covent Garden the heat loss through the solid brick walls was obviously high, and Pepys and other guests 'were fain to lie in our stockings and drawers and lay our coats and clothes upon the bed.'[126] Although heavy fabrics may have been draped around windows, doors and used as bed hangings in some instances to reduce draughts, these materials would not have significantly improved thermal insulation. The reliance would therefore have been on the second factor stated earlier, an efficient heating system.

The earliest forms of heating in early modern London came from the burning of wood, peat and other combustible materials on an open hearth, or in a container such as a brazier. Smoke would find its way out through roof vents or gaps within the covering.[127] With a demand for increased levels of comfort, particularly in the context of much colder winters, open fires gave way to an increased use of fireplaces, with associated flues and chimney stacks.[128] Margaret Spufford has observed that very little work has been done on the type of fuel consumed, despite some probate inventories describing the contents of people's woodsheds and yards.[129] Such information would only be available for the wealthier sections of society but the

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[125] Ibid. p.388

[126] Pepys, *The Diary*, January 15th, 1666.

[127] Watt and Swallow, *Historic Buildings*, p.184; Schofield, *Medieval London Houses*, pp. 113 and 116-118.

[128] Spufford, 'Chimneys, Wood and Coal' p.23.

[129] Ibid. p.25.

implications of availability and the cost of fuel are considered in greater detail in the Chapter 7. The end of the sixteenth century saw sea coal as an alternative to wood, requiring the use of fire baskets instead of firedogs and/or irons.[130]

As noted in Chapter 4, the Treswell plans show that by 1600 even the smallest houses he surveyed in London possessed a chimney and had fireplaces in several rooms. Some of the basic shed structures in the post-Fire period also had provision for heating. There are eighteen certificates produced by the Surveyors and Viewers on sheds in the post-Fire era and four of these are described as having chimneys, including one inspected in 1675 by the City surveyors, Hooke and Oliver. The Surveyors reported on 'the building of esq. Thomas' who had built in his back yard 'a shed of timber two storyes in height […] wherein is made a chimney for burning shavings and heating their stove…'[131] This certificate is also useful in describing the type of fuel.

There are various levels of analysis regarding the function and performance of fireplaces and chimneys. Fire hazards, as with other forms of accident, are outside the scope of this thesis. The good design of a chimneystack, flue and fireplace is essential to meet functional requirements; the performance of the fire in action would be dependent upon the quality of construction and materials, regular maintenance to the flue and stack and the quality of the fuel.[132] Hollis has set out the parameters for the design of an efficient open fire: the flue should be at least 200 mm in diameter; a large open fire will require a chimney that is at least 15 per cent of the area of the fire; the provision of a 'throat' or a tapered neck in the flue will decrease the chance of smoke blowing back into a room with a down draught; the height of the chimney will influence the performance; a good chimney will suck out the smoke from the fire.[133]

There is a lack of detailed information on the design of pre-Fire fireplaces and flues in London. Although there are illustrations of fireplaces internally and chimney stacks externally, these do not provide enough information to determine how well the

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[130] Watt and Swallow, *Historic Buildings*, p.184; Schofield, *Medieval London Houses*, pp. 113 and 116-118, see also Spufford, 'Chimneys, Wood and Coal' p.25.

[131] LMA COL/SJ/27/471, Vol II.28.Oct 17, 1675.

[132] Spufford, 'Chimneys, Wood and Coal' pp.22-31.

[133] Hollis, *Surveying Buildings*, p.364

chimneys and fires functioned, particularly with the change in the type of fuel which was burnt. As already noted, the chimneys had been built for burning wood, which needs different management from that of coal. The Viewers only reported on the repairs and position of chimneys and the occasional complaint of smoke affecting neighbours. Although the Rebuilding Act of 1667 covered many aspects of house construction, there was no specification for the improvement in the function and performance of chimneys. The only aspects that were mentioned, related to preventing the spread of fire.[134] It would appear that chimneys were rebuilt, or in the case of new houses, built in much the same way before the Fire. It was not until the experiments conducted in the late eighteenth century by Robert Clavering that some assessment of the design of chimneys to buildings long since swept away could be made.[135] Although Clavering produced his findings after this study period, his critique of the failings in the function and performance of chimneys includes an analysis of heating in the sixteenth and seventeenth centuries.

Clavering described himself as a builder, with the experience of 'building several houses' upon which he 'began to try experiments' in the construction of efficient chimneys.[136] Along with his 'experiments' he consulted with 'several able bricklayers' but the results of his investigations did not offer 'encouragement for the best regular theory of the construction and building of chimneys.'[137] He concluded that the design of efficient chimneys had been 'neglected' and failed to 'ascertain the principals of a conveniency, the due execution of which is necessary to render every habitation comfortable, from cottage to palace.'[138] Thus, his findings were pertinent to heating the houses of all social groups.

Clavering's recommendations are based on the want of good design; his *Essay* was significant in that he addressed the same requirements identified by Hollis in the modern era. He suggested specific sizes of flues according to the dimensions of the

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[134] An Act for rebuilding the Citty of London' pp. 603-612, see the Appendix. Date accessed: 28 October 2012.

[135] Clavering, *An Essay*, pp. 2, and 96.

[136] Ibid. p.iv.

[137] Ibid. p.2.

[138] Ibid.

room and he produced a 'table' explaining his theory, based on 'Geometrical Principles.'[139] He also observed that the throat would prevent the penetration of rain, hail or snow falling into the fireplace, as well as preventing smoke drifting back into the house 'absolutely necessary' for 'no situation in life can be more uncomfortable and unhealthy than residing in a smoky house: it is not only offensive to our sensations, but destroys all domestic enjoyment.'[140] Clavering considered that the poor performance of chimneys would be to the detriment of occupiers' health.[141]

He observed how chimneys drew air through houses and he was describing an important performance requirement.[142] The height of the chimney will influence its effectiveness and tall chimneys are shown in the foreground of various panoramas of the study period.[143] Thus, maintaining the condition of a chimney stack was essential in order that it could draw-out the smoke from the fire. Its performance, however, would also have required a ready supply of air into the room because it would have relied upon a through-flow of air from the room to lift the smoke and burnt gases to roof level. Thus, poorly ventilated houses in congested early modern London might often have failed to meet this requirement; ventilation is considered in the next sub-section of this Chapter. Clavering considered that a significant defect in chimneys was caused by 'external obstruction' such as those produced by 'higher buildings; greater elevation of ground, such as hills…'[144]

Thus, the houses in the lanes, yards and alleys behind the taller buildings in adjacent streets would have required relatively higher chimneys. Raising the heights of chimney stacks was only pursued in environmental law where smoke was creating a problem to neighbours; one particular example involved Mr. Legg, who was 'very much prejudiced and annoyed by the smoake of a chimney belonging to the

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[139] Ibid., p.34.

[140] Ibid., pp. 2, and 96.

[141] Ibid., pp. 65-67.

[142] Ibid., p.95.

[143] For example, Wyngarde's of 1543, Van Visscher's of 1616, Hollar's of 1647.

[144] Clavering, *An Essay*, p.6.

bakehouse of one William Muggleton, his neighbour.' [145] Muggleton's bakehouse was located in Coleman Street, near the junction with Lothbury in the city centre, and the Viewers were of the opinion that he should build the chimney higher 'so as to remove the smoake over the topps of the houses.'[146] Another post-Fire case involved the surveyors' response to a grievance by Messrs. Allen and Lyme and 'other inhabitants in the parish of St. Mildred Virgin' who complained that a Mr. Clark 'hath built a shedd of timber and boards in the church yard of the aforesaid parish' where 'smoke coming out of the said shed [was] to the annoyance of the Neighbourhood.'[147] The height and mass of these chimneys meant that they required substantial foundations but there is only one report where the Viewers are specific in their description of a failure in the structural performance, and this occurred to a property in the parish of St Magnus where 'a floor that a chimney stands on is sunken and must be amended.'[148] It is possible that other structural problems were the reason for Viewers certifying that other stacks be 'amended', but the description of repairs are generic.

The preceding Chapter described how the performance of chimneys would be affected by the lack of repairs. In one extreme case in 1594, a chimney to a property in All Hallows Honey Lane collapsed. This appears to have resulted from neglect as the building, which was owned by the Mercers' Company, was reported as being dangerous in 1591.[149] The exposed position of the chimney stacks meant that they were generally prone to deterioration through weathering, frost action and atmospheric pollution, leading to rapid deterioration of the fabric and eventual loss of stability. There are numerous Viewers' reports referring to 'amending of chimneys'[150] and the repairs to these exposed structures are frequently referred in the *Cheapside*

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[145] LMA/COL/SJ/27/471/Vol.II. III. 1679.

[146] Ibid.

[147] LMA COL/SJ/27/471, Vol. II.32, June 20 1676

[148] *London Viewers*, 109 [B.104] 4 July l534.

[149] Keene and Harding, 'All Hallows Honey Lane 11/8', *Cheapside Gazetteer*, pp. 48-78.

[150] For example, see *London Viewers*,109 [B.104] 4 July l534.

Gazetteer such as the purchase of '100 bricks' between 1531 and 1536 'to mend a chimney' to a property in Soper Lane.[151]

Defects affecting performance could occur more frequently through poor workmanship and materials. Clavering noted that one of the most significant problems with chimneys was 'faulty construction.'[152] Unless the bricks from which the chimney stack were constructed of a hard, dense quality and properly fired in the kiln, they would have required regular repairs. It has only been a requirement since the Second World War for damp-proof courses to be inserted into chimneys to prevent the direct down penetration of rainwater into the building.[153] Repairs in early modern London were often stipulated as a condition of the granting of new lease and therefore the stacks may have been left in a poor state of repair for a long period of time, resulting in rebuilding rather than repairing in many cases.

The performance of fireplaces would also be related to the type of fuel referred to earlier, but any significant differences in heat generated in the burning of wood or sea coal would have been reduced due to one important short-coming in open fires; most of the heat would have disappeared up the chimney and it was estimated at the start of the twentieth century that a mere 14 per cent of the heat from an open fire actually benefits a room.[154] Ironically the elaborate fireplaces of the middling sort and upper classes were not effective room-heaters; the materials such as stone absorbed much of the heat. Rumford described accurately the relatively better performance of a small fireplace lined with non-heating conducting material such as fireclay or brick; it was much more efficient and economic.[155]

The burning of wood and coal in the chimneys could also bring about different forms of deterioration to the interior of the flues, resulting in damage to the chimney breast within the building.[156] Coal was a dirty fuel option; it was more

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[151] Keene and Harding, 'St. Pancras Sopers Lane 145/42, *Cheapside Gazetteer*, pp. 750-753.

[152] Clavering, *An Essay*, p.6.

[153] Melville *et al*, *Structural Surveys*, pp.78 and 104.

[154] Hermann Muthesius, *The English House* (1904), cited in Hardyment, *Behind the Scenes: Domestic Arrangements in Historic Houses* (National Trust Enterprises, London, 1997), p.182.

[155] Rumford, *The Complete Works*, pp.182-4.

[156] Watt and Swallow, *Surveying Historic Buildings*, p.186.

'uncyious and weighty' and the waste particles readily stuck to the interior of the flues and created more smoke than wood fires had.[157] The burning of damp wood would cause condensation problems on colder sections of the flues; burning of coal would produce sulphates and set up a chemical reaction leading to the deterioration the bricks.[158] It is not certain whether such defects were the reason for artisan Wallington having to replace crumbling brickwork to a chimney breast under the terms of his new lease.[159] Pepys has recorded the deterioration to the interior of the flues in his description of bricklayers replacing defective bricks to a chimney that was smoking profusely.[160]

As noted in Chapter 5 and summarised in the Audits, the thermal capacity of early modern houses was low; in other words it would take a considerable amount of heat over a protracted period of time to provide a surface temperature to the walls capable of resisting the build-up of condensation and general dampness. This was recognised by Clavering who advocated long periods of heating to counteract such problems.[161] As is the case with most of the services considered in this Chapter, the variation in the quality of servicing a building between social groups can only be viewed in relative rather than absolute terms; open fires were and still are a very ineffective way of heating a building. This Chapter has drawn on evidence focusing on the heating of dwellings in the wealthy city centre and it is clear that the standard would not have been high enough to provide thermal comfort during a typically cold winter in the northern hemisphere and the situation would have accentuated during 'the Little-Age'. As noted, such conditions would also have promoted extreme dampness through condensation.

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[157] Clavering, *An Essay*, p.95.

[158] Watt and Swallow, *Surveying Historic Buildings*, p.186.

[159] Seaver, *Wallington's World*, p.58.

[160] Pepys, *Diary*, II, p.22.

[161] Clavering, *An Essay*, p.67.

6.3.iii Inadequate ventilation

The interaction of two different aspects of the 'hygrothermal environment' in the early modern context has been identified with Clavering stating the importance of ventilation to the performance of an open fire.[162] Ventilation also interacts with daylight in the study of windows but the former can be achieved by other means. Two different forms of ventilation are referred to in the modern Building Regulations pertaining to indoor air quality.[163] The first concerns the provision of fresh outdoor air to occupied areas of a building, and the second is the circulation of air within a dwelling but does not necessarily include the addition of any fresh air.[164]

Erasmus observed in a slightly earlier period that in London's houses 'chambers are built in such a way as to admit no ventilation […] a great part of the walls of the house is occupied with glass casements which admit light, but exclude the air.'[165] J.T. Smith has drawn buildings in London dating from the seventeenth century with continuous rows of double-height windows, usually on the first floor of a gabled property.[166] One of the houses drawn by Smith is south of Crutched Friars and has three sides of a highly decorated courtyard, with continuous windows lighting a first floor suite of chambers.[167] The main facade of a property in St Mary le Bow, documented by Keene and Harding, appears to be represented in a contemporary painting of Edward VI's coronation procession through Cheapside and shows a two-light window in each bay on each storey, making 14 windows in all.[168] For an assessment of ventilation, however, consideration needs to be given to whether such windows were purely fixed panes of glass, or included some opening casements.

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[162] Ibid. p.6.

[163] *Building Regulations 2000,* Part F.

[164] Mood, 'Fundamentals of Healthful Housing', p.328.

[165] Quoted in Brett –James, *The Growth of Stuart London,* p.100 footnote 11.

[166] Schofield, *Medieval London Houses,* Figs. 111-113, pp. 101-2.

[167] Ibid.

[168] Keene and Harding, 'St. Mary le Bow 104/20', *Cheapside Gazetteer'* pp. 283-293, date accessed, 21 October 2012.

Requirements for an acceptable amount of fresh air in buildings will vary depending on the nature of the occupation and activity therein.[169] Consideration should be given at this point to the ventilation requirements and whether they were achieved. Air changes per hour or 'ventilation rate' are the preferred modern criteria for assessing the adequacy of the building. This is calculated by dividing the quantity of air by the room volume and multiplying by the occupancy, for example: 50 cubic metres per hour, 100 cubic metre room for five persons: 50/100 x 5 = 2.5 air changes per hour.[170]

As noted in Chapter 3, Treswell rarely showed windows on his plans, but they are included in his plans for 34 Bow Lane. Although the width of windows is not given, a rough estimate can be made taking a scaled measurement from the plans. The heights of the windows are also omitted but we can see from Treswell's drawing of the elevations of part of Cheapside that these were often at least half the storey height, that is between four and five feet; drawings by artists such as Smith and Carter confirm this proportion of window height to storey height. It is the size of the opening casements, however, which is crucial to this investigation. To prevent the build up of high humidity in dwellings, Part L of the current Building Regulations stipulates that 8,000 square millimetres of opening windows should be provided for all habitable rooms and 4,000 square millimetres for kitchens.[171] Frequent reference is made in documentary sources to the main functional requirement of windows to provide light, with no reference to ventilation. In a property in St. Mary le Bow for example 'two windows in the house were pulled down and repaired in order to increase the light in the cellar. In that operation two of the existing windows casting light into the cellar from Cheapside were probably enlarged.'[172]

As observed in Chapter 4, environmental law recognised the requirement for windows to provide ventilation as well as light.[173] One contemporary lawyer argued that two lights on the front and back of house were sufficient for the entry of air and

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[169] Hall and Greeno, *Building Services*, p.158.

[170] Ibid.

[171] The Building regulations 2000 HMSO.

[172] Keene and Harding, 'St. Mary le Bow 104/20', *Cheapside Gazetteer*.

[173] The Proclamation of 1619; Knowles and Pitt, The History of the Building Regulation, p.20; 'James I: *Calendar of State Papers Domestic: James I, 1619*'.

light[174] and yet there is no reference to this being enforced by the Viewers or it being a condition under the terms of a lease. There would have been more opportunity for appropriate ventilation rates being achieved in one-room deep houses as long as they were not backing onto neighbouring properties. This is a significant point, emphasising once again how the surroundings to a dwelling, including neighbouring properties, could influence the internal environment.[175] Thus, the analysis of the first form of ventilation, the provision of fresh outdoor air to occupied areas of a building, has proved problematic. Despite the numerous windows mentioned in early modern leases and depicted in drawings, there is a lack of evidence relating to the number of opening casements. There may have been some compensation by the opening of external doors but this would have been limited to ground floor areas, and not necessarily provided through ventilation.

No evidence has been found suggesting the 'second meaning' of ventilation was recognised, but the circulation of air within the building would have been achieved indirectly through other means. As noted in the last Chapter, structural movement as well as movement caused by natural shrinkage of materials in buildings would have produced cracks in the fabric and gaps would have opened up between wattle and daub and timber frames; ventilation would have therefore occurred by filtration. Erasmus observed that many windows in London's houses 'let in the draft through holes and corners.'[176] The lack of sufficient ventilation, however, brings with it high humidity in the air, dampness in the walls, and the propagation of mould and harmful spores circulating within the internal environment; such conditions would have exposed the occupants to respiratory diseases.[177] It was noted in Chapter 5 that a number of floor timbers above cellars in Cheapside were reported to be suffering from decay, even though this elevated part of the city centre may have been less

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[174] Monson, *A Briefe Declaration*, p.14.

[175] As discussed in the last Chapter, poorly built adjoining neighbouring properties could cause damp ingress; this Chapter has identified the affects of tall neighbouring buildings on the performance of chimneys.

[176] Quoted in Brett –James, *Stuart London*, p.100 footnote 11.

[177] Collins, 'Cold and heat related illnesses' pp.145-6.

susceptible to rising damp.[178] Dampness in the form of extensive condensation will develop in poorly ventilated subfloor areas.[179]

The contemporary medical theories on 'bad airs' were discussed in Chapter 2, and as far as the eminent contemporary physician Richard Mead was concerned 'nothing approaches so near to the first Original of *Contagion*, as Air pent up, loaded with Damps.'[180] We noted earlier that the phrase 'damps' was associated with a deadly gas. Such gases are odourless, however, and give no warning, so it was possible that Mead was referring to anecdotes of death caused by the exposure to carbon dioxide and methane gas, while experiencing the smells produced by damp and mould in poorly ventilated internal environments. The circulation of air within the building would have been difficult to achieve if we consider the plans produced by Treswell: the narrow street frontages and the configuration of rooms with intervening partitions on each storey. These factors would have impeded the circulation of air within the dwelling. There is always a degree of movement of the air within a building, however, and a number of air changes take place each day through the walls alone. This means that there is a risk of the build-up of moisture within a wall when the warm moist air generated from activities meets the cooler external part of the wall. The theory is that the moisture that had to be carried by the air is deposited within the wall. This should occur when the internal temperature of the air is above its dew point and results in 'interstitial condensation'.[181] The Audits show the rate of heat loss through the walls, confirming the surface temperatures would have been cold and prone to condensation and would produce mould in the buildings of all social groups.

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[178] As noted in Chapter 5, the recent excavations in the *New Change Excavation* found that the cellars were relatively dry.

[179] Hollis, *Surveying Buildings*, p.39; Watt and Swallow, *Surveying Historic Buildings*, p.101.

[180] Mead, Richard, *A Short Discourse Concerning Pestilential Contagion*, or the Plague, *with the Methods to be used to Prevent it* (Dublin: reprinted by and for George Grierson, 1721; Michigan, U.S.A., Gale ECCO, 2010) pp.40-1.

[181] Hollis, *Surveying Buildings*, p. 425.

6.3.iv The lack of daylight within buildings

As noted at the start of this thesis, the contemporary lawyer Robert Monson expressed an early modern expectation regarding the function of windows; to him they were not only critical for ventilation but also for 'the receipt of comfortable light…'[182] Researchers into housing in the modern era have observed that the penetration of direct sunlight into dwellings produces favourable psycho-physiological effects on both thermal comfort and the biological activity of humans.[183] A healthful house is one in which the occupants are provided with the possibility of obtaining maximum benefit from both natural and artificial lighting, to the extent they desire to perform various household and leisure activities. During the day, natural light should illuminate dwellings or at least the principal rooms of buildings. As already noted, daylight can destroy some bacteria.[184] Also, since direct sunlight will contain some infra-red rays, there is usually a warming or heating effect which would have mitigated the relatively poor performance of fireplaces of some early modern houses. Thus, the benefits of natural lighting to physiological requirements are clear but in reiterating the interaction of aspects of the 'hygrothermal environment', heat-loss through walls dominated by large areas of glazing would have been considerable.[185]

With regard to early modern London, it appears that large areas of glass was not just fashionable but a 'trade-off' with heat-loss, to avoid the dwelling resembling more 'a dungeon then a house.'[186] This is not only borne out by the pictorial evidence of windows detailed by the artist, such as those referred to in Chapter 3, but also the increase in the number of right to light cases during the study period. Many windows in the city were blocked up or light was significantly reduced by the continued expansion of the city and the infilling of neighbouring vacant plots. This widespread

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[182] Monson, *A brief Declaration*, p.1.

[183] Mood, 'Fundamentals of Healthful Housing', p.329.

[184] Ibid.

[185] See heat calculations to all house types in the Audits.

[186] Monson, *A Brief Declaration*, p. 14.

issue led to Monson calling upon the opinion of four eminent judges regarding rights to light. It is significant, however, that only two of the judges agreed with Monson in viewing the loss of light from a health aspect.[187]

As already noted, the presence of glass in windows can make some contribution to warming a house and therefore can be considered as being beneficial to health. Glass was in common use during the early part of the study period[188] and there are detailed accounts of its presence in inventories of properties in the city centre. In 1598 the following was described in a schedule of fittings for a property in St Mary le Bow, Cheapside: 'a great parlour with a bay window containing 21 panes of glass […] a little parlour with a bay window containing 12 panes of glass; a counting house; a chamber over the little parlour with a bay window containing 5 panes; a great chamber over the great parlour with a bay window containing 12 panes.'[189]

No similar detailed accounts of unglazed windows have been found even though they must have existed, particularly in the houses of the poor. Schofield only refers to unglazed windows in the medieval context, with shutters inside the window, sometimes sliding from side to side in grooves.[190] Watt and Swallow describe unglazed masonry windows, with narrow openings or loops cut through a wall or with splayed reveals for light and ventilation, which developed from the eleventh to the thirteenth century.[191] In contrast, unglazed timber windows typically comprised square section oak mullions set diagonally into a surrounding frame, with internal horizontal sliding shutters, or hinged shutters set either side externally.[192] If these unglazed windows were in common use, then they tended to be at ground level.[193] It therefore follows that if these unglazed windows were on opposite sides of a building,

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[187] Ibid. pp.2, 11-13 and 21-4.

[188] Schofield, *Medieval London Houses*, pp. 99-105.

[189] Keene and Harding, St. Mary le Bow 104/24', *Cheapside Gazetteer* pp. 313-325. Date accessed: 28 October 2012.

[190] Schofield, *The Medieval London House*, p.108.

[191] Watt and Swallow, *Surveying Historic Buildings*, p.163.

[192] Ibid.

[193] Schofield, *The Medieval London House*, p.108.

without internal obstructions, then there was an opportunity for good ventilation but no possibility of solar heat gain.

Leases and inventories also provided evidence of numerous windows squeezed into elevations. Behind a main block to a property in St Mary le Bow was a yard, not leased with the property, 'onto which the back windows of the cellar and shop, and the windows of the great parlour and great chamber all opened. The windows of the kitchen, which seems to have been behind the main block and linked to it by the gallery, probably also overlooked the yard. Some of the upper rooms had windows on to the gutters or leads, suggesting that different parts of the house rose to different heights. All the main rooms including the kitchen had windows glazed and barred with iron.'[194]

It is not certain whether the fenestration of some early modern buildings reflected the fact that north-facing elevations received less light, and larger windows were necessary to compensate for this. Caution must be exercised in drawing such conclusions when reading the description of early modern buildings, for example some houses in St. Mary le Bow were described as having 'larger windows to the front (North) and smaller backward.'[195] The variation in window size may merely be due to front and rear elevations being built in different styles. These houses in St. Mary le Bow were of a similar size, one room to each floor, with a cellar, three floors, and garret.[196] Some modern writers have argued that one-room deep houses such as these were 'planned' in order to maximise the light entering the buildings.[197] The contemporary architect John Gwynn also commented, 'Another error which contributes towards making rooms dark, is making them too deep.'[198] Thus, one-room plans in themselves were not the solution to achieving sufficient daylight, the depth of the building was also a factor. It could also be argued that the one-room plan house was also governed by the size of the plot. Nevertheless, Cockayne argues that as long

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[194] Keene and Harding, 'St. Mary le Bow 104/11', *Cheapside Gazetteer,* pp. 244-251.

[195] Ibid.

[196] Ibid.

[197] Guillery, *The Small House,* p.60; Cockayne, *Hubbub,* p.147.

[198] John Gywnn, *London and Hammersmith Improved*, (London 1766), p.129, cited in Guillery, *The Small House,* p.60.

as such houses had a window in more than one wall, then the shallow depth of these houses would have countered some of the darkening effects of being shoehorned into a small court.[199] Ralph Treswell's surveys of a complex building on London's Monkwell Street (1692) shows a group of five houses on a one-room plan, in a court, each two storeys plus a garret high (Figure 6.03).

The counter argument to this point is that smaller one-room deep houses would still have been dark where they were built in courts behind larger houses fronting the street. Away from the generally higher buildings of the city centre, the one-room layout might reflect the 'user requirement' for good interior lighting, particularly where the upper-storey rooms might have expected to be used all day long as work shops. Guillery has made this point in his account of the workshop tenements in London's silk-weaving district of Spitalfields.[200]

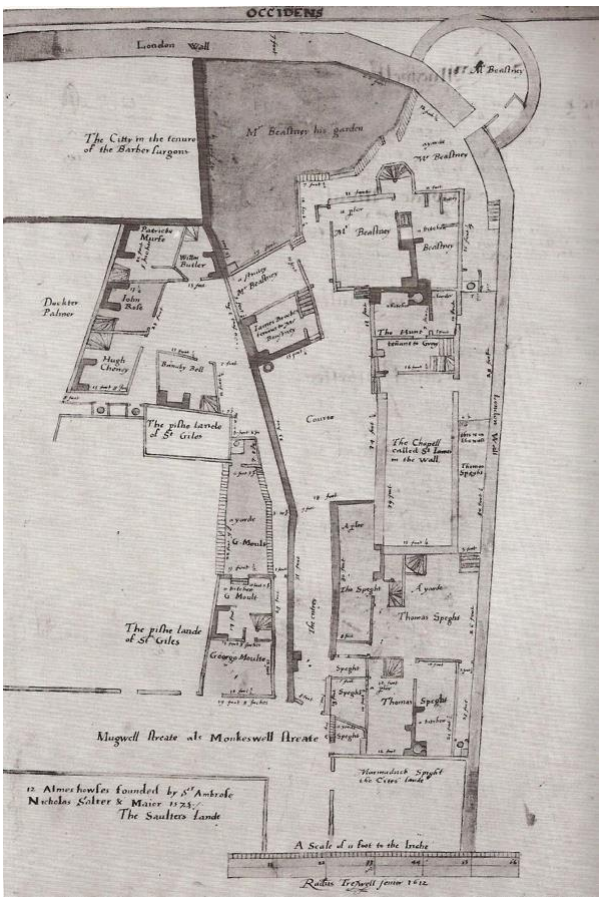

Figure 6.03. St James' Hermitage/ Lambe's Chapel, Monkwell Street.

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[199] Cockayne, *Hubbub*, p.147.

[200] Guillery, *The Small House*, pp. 60 and pp. 70-115.

Some wealthier citizens of early modern London, however, also lived in courtyard houses,[201] and a plan produced by Treswell of 47-48 Fenchurch Street provides one such example. Such a house is considered by Schofield to represent a middle-sized dwelling within the city centre with several rooms on each floor.[202] This particular property was occupied in 1612 by a relatively wealthy Jacques de Bees, whose dwelling had no street frontage at ground floor level, and his spacious hall was reached via the passage between two neighbouring dwellings at the front. Treswell's plan of a large property behind a row of small houses along Billiter Lane shows how even the houses of the very wealthy would have to compensate for limited light by the inclusion of a significant amount of windows. Although this was a very large building in plan, it was only two storeys in height.[203] The courtyard house south of Crutched Friars was referred to earlier where three sides of the building had continuous windows. The high quality of the decorative windows suggests that this was the house of a wealthy person.[204]

The increasing sources of industrial and domestic air pollution noted in Chapter 3 would have further reduced available light and have provided greater incentive to increase the number and size of windows. It would appear that artificial light could not be relied upon. Schofield refers us to the use of torches, oil lamps and candles.[205] Cheap yellow candles were made using inedible mutton or beef tallow collected from butchers and domestic kitchens; these gave a dim light and we can conclude that artificial lighting was poor.[206] New buildings could obstruct the light enjoyed by existing neighbouring premises. The Viewers noted in one case that a Matthew Bluck had 'erected four houses upon new foundations in the parish aforesaid adjoining to the East and North East of the said parish church [St. Peter Le Poor,

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[201] Power, 'The social topography', p. 209.

[202] Treswell, *London Surveys*, p.159.

[203] Ibid. p.74.

[204] Schofield, Medieval London Houses, p.102.

[205] Ibid. p.128.

[206] Cockayne *Hubbub*, p. 146 fn. 149.

Broad Street] very much obstructs the Ancient Light of the said parish church.'[207] In Bishopsgate Without, in the same year, the surveyors reported on a complaint that four 'new houses upon new foundations...hath damaged and darkened the ancient lights...' to neighbouring properties.[208]

By definition the phrase 'Ancient lights' states the limitations of the remit of the Viewers and Surveyors. They could not enforce such rights if an aggrieved party had rebuilt a house that included significant alterations. In 1678 Jarvis Wilcocke alleged that a neighbour and widow called Susanna Ware had rebuilt her property in Trinity Court, Aldersgate Street, which had the effect of 'darkening of lights' to his property. The Surveyors observed:

> '…we find that by erecting of [the] house higher than formerly it darken part of a Garrett Light made in the Dormer of the house belonging to Jarvis Wilcock, fronting towards the Court aforesaid that part of which light that will be darkened is therefore of the following dimensions. Four foot and six inches or thereabouts at the toppe and four foot in height or thereabouts all [?] one side therefore the light being made attending to the roof of the Dormer.' [209]

The Surveyors referred to the records of the original building belonging to Wilcocke and noted that he had rebuilt his house before Susanna Ware 'higher than the Ancient house belonging to the Ward.'[210] The Surveyors determined that Wilcocke's new and different house had no rights to light and no action could be taken against the widow Ware. The Surveyors, under the leadership of the pragmatic Robert Hooke, saw a solution for Jarvis, however, who could construct 'a light in the Roof of this [his] Garrett' aforesaid to supply the light that now will be darkened by erection of the said [Ware's] building.'[211] The same principle also applied in terms of internal alterations, as was demonstrated when the Surveyors did not uphold a complaint in 1688 by 'Esquire Andrews' pertaining to his property in Bishopsgate

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[207] LMA/COL/SJ/27/469/92.9 May 3 1667.

[208] LMA/Col/SJ/27/471. Vol. III.42 [month not legible] 1667.

[209] LMA/COL/SJ/27/471/Vol.II.91, April 9 1678.

[210] Ibid.

[211] Ibid.

Street, near Walnut Tree Yard.[212] In describing the layout of the buildings belonging to both parties, the Surveyors note a significant point that was missed by the Viewers in a previous view.[213] The plaintiff, Andrews, had made alterations to his buildings, which were 'irregularly conceived...Rooms of the said houses of Esquire Andrews were divided into more' and as a result the Surveyors concluded that his property 'did not have any Ancient lights.'[214] Thus, buildings that had rooms of a different configuration to the pre-Fire period could be starved of natural light.

Although the Surveyors' remit was to ensure that the new brick built houses were to comply with the Rebuilding Act, and not obstruct 'Ancient light', it is significant that approximately thirty-five per cent of the post-Fire rights to light issues arose through the construction of sheds, usually in back yards.[215] Providing the claimant's property had been rebuilt along its original lines and internal configuration of rooms, action could be taken against the builders of sheds.

6.4 Conclusion

This Chapter has brought the investigation from the exterior into the interior by considering how the buildings were serviced. The interaction of the external and internal environments, however, has been made clear in the case of all the services. Water was brought into the dwellings by various sources, with suggestions that the quality had already been compromised by the time it reached the occupants. Early in the study period environmental law specified that privies should be located at certain distances away from neighbouring buildings but did not seem to regulate their position in relation to the building they were serving. Convenience appeared to dictate the location of many privies, which brought them in close proximity to the building, particularly in the case of kitchens. The gradual development of confined city centre plots also lead to the privies being adjacent to or within the dwellings as

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[212] LMA COL/SJ/27/417.Vol. III.63 20 June 1688 LMA COL/SJ/27/417. Vol. III.65 2 July 1688

[213] Although the viewers looked at this initially on the 20 June 1688, Hooke and Oliver were instructed to also view the same property on 2 July 1688. This would suggest that there might have been some form of appeal against the decision by the Viewers.

[214] Ibid.

[215] I have calculated this from the cases entered into my database.

outside space was reduced. The study of the hygrothermal environment of London's early modern buildings has also emphasised the interaction of the external and internal environments and particularly the relationship between heating, ventilation and daylight. The essential balance between a sufficient number of fireplaces and opening windows in order to provide a healthy internal climate was almost impossible to achieve due to the inefficiency of open fires, the extremities of the climate and high-density building restricting ventilation and daylight.

This study in the servicing of buildings, and the way in which these services were arranged and used, has provided a valuable means of understanding the 'user requirements' and expectations of those living in early modern London. The quality of services was largely reliant upon the means and willingness to pay for them and the ability of the servants or contractors involved. The provision of services was mainly confined to basic comfort and considerations of health came later. Thus, conflicting 'user requirements' had a significant role to play in defects manifesting in the services of the buildings. As in the case of failures in the structure and fabric of the buildings, poor maintenance of the services contributed to inherent defects in their design and construction and compromised the two fundamentals of healthful housing. Thus, the failures in the building services would have provided conditions conducive to the enteric and respiratory complaints and Chapter 7 will consider variations in such conditions in different residential areas over time.

PART III: Social Epidemiology

Chapter 7

The social relationship between housing and health

The aim of this thesis has been to comprehend the influence of building policies and practice on the health of London's early modern population within the framework identified in Chapter 2. The main lines of the conclusions to this thesis emerge in the building pathology Chapters 4-6. As mentioned in Chapter 1, the archival research and information come second in this Chapter in the exploration of 'social epidemiology'. Nevertheless, the aim of this Chapter is to draw on the conclusions of the building pathology analysis to assist in this enquiry into the central concept. 'Social epidemiology' was introduced and defined in the opening Chapter and the justification for conceptualizing the impact of differential housing conditions on the aggregate health of whole communities, spatially and residentially defined was made in Chapter 2. This was based on the compelling case put forward in 1993 by David Byrne and Jane Keithley, researchers into the pathology of buildings whose approach to 'social epidemiology' is informed by a 'realist' epistemology and deals precisely with the causal systems of diseases.[1]

Byrne and Keithley provide an example of this approach in the 'construction of the Moyard Health Profile' in west Belfast in 1986.[2] The research project found that the proportion of low birth weight babies, whose mothers lived in Moyard, was almost twice that for North and west Belfast District and over twice that of the proportion for the Eastern Board as a whole. This was a significant finding because it is now generally accepted that low birth weight can be used as a modern alternative to historical research into infant mortality. The incidence of the latter was paramount in the promotion of slum clearance during the interwar period.[3] In the absence of slums in modern Britain, birth weight is now considered the single most important factor of

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[1] Byrne and Keithley, 'Housing and the Health of the Community', p.56.

[2] EHSSB Working Party, *Moyard Health Profile,* (EHSSB 1985).

[3] Byrne and Keithley, 'Housing and the Health of the Community', p.61.

a baby's future health[4] and served as a key morbidity indicator at the ward level in Townsend *et al's* study of health in the north of England.[5] Byrne and Keithley have drawn the following conclusion from the Moyard project:

> Given this simple and […] easily obtained piece of information, we can say that we have an indication of poor health in aggregate of Moyard babies; and given the certainty of variation in individual birth weights among Moyard babies, this is far more appropriate as a way of looking at the situation than an analysis which wrote 'Moyard' to a variable set for each baby and explored the influences of location on birth weight.[6]

This conclusion not only reinforces the value in analysing aggregate data as a means to determine the healthfulness of the built environment, it also highlights the point made in the opening Chapter: mortality in early modern London must also be considered in the context of morbidity. The constant exposure to poor housing conditions may have brought about premature death in the study period. Infant mortality in early modern London was high but for those children who survived regular bouts of illnesses, particularly of a respiratory nature, life expectancy was low.

In the same year Byrne and Keithley put forward their argument for the application of social epidemiology in the modern era, the historian Justin Champion considered a similar approach in his 'Epidemics and the built environment in 1665.'[7] Champion suggested three approaches in which relationships between mortality and human environment can be explored and understood. The first would be to investigate the material connection between the location of death and the quality of the urban environment, particularly in terms of the size and value of the housing. The second method would be to focus upon spatial differentiation: 'understanding the variations between distinct localities within the city by calculating an overview of patterns of death in a city-wide or local context.'[8] The third would be to pose questions in terms

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[4] Jean Conway 'Ill-health and homelessness: The effects of Living in Bed-and-breakfast accommodation' in Burridge and Ormandy *Unhealthy Housing,* p.294.

[5] P. Townsend *et al, Health, Deprivation and Inequality* and the North (Croon Helm, London, 1988).

[6] Byrne and Keithley, 'Housing and Health of the Community', p.56.

[7] Champion, 'Epidemics and the built environment'.

[8] Ibid. p.1.

of the seasonality of such relationships between wealth and disease: 'what parts of the city suffered the biggest mortality crises and at what time of year? How did the disease move around a local area? What type of households suffered at particular points in time?'[9] Thus, in all but name Champion engaged important aspects of 'social epidemiology' and the three approaches he put forward form the template to this Chapter.

As noted in Chapter 2, Champion considered that it is possible to relate deaths to places in early modern London, but he identified problems in trying to characterise the social structure and the quality of housing for any particular parish in the city.[10] He was making these observations in the context of the plague and in a particular year and consideration needs to be given to whether his methods can be fully adopted in this enquiry into the 'social epidemiology' pertaining to enteric and respiratory complaints throughout the study period.

7.1 Variables in the relationship between mortality and the urban environment

Champion identified three variables in order to accomplish the 'historical objectives' set out above: one to describe the patterns of death, the second to quantify the quality of housing conditions, and the third required some form of contemporary cartographic material upon which it would be possible to map the other variables.[11] With regard to patterns of death, he suggested drawing on the aggregate data in the Bills of Mortality; the currency of this source was discussed in the first two Chapters of this thesis. Champion also draws attention to supplementary information that could be obtained from manuscript burial registers and although they are variable in quality and survival rate, he suggests they can nevertheless provide important data about the age, gender, status, occupation and location of the dead within individual parishes.[12]

Champion considers that it is possible to use the Hearth Taxes of the 1660s to describe the structure of the household wealth of most parishes of metropolitan London. Once this is established a comparison of the mean size of houses in terms of

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[9] Ibid.

[10] Ibid, p.1

[11] Ibid. pp.1-2.

[12] Ibid. p.2.

hearths can be made along with the number of rich and poor households, the ranges of house sizes and density of housing, with a profile of the population that died derived from the general weekly account contained in the Bills of Mortality or specifically from individual burial registers. Champion suggests that it is possible to correlate the size of the epidemic crisis in each parish with the average hearth size. He calculated this by dividing the number of deaths in 1665 by the mean figure for the previous decade.[13] There are difficulties, however, in attempting to make a similar analysis of enteric and respiratory complaints. As noted in Chapter 4, although enteric complaints are quite prominent in the Bills of Mortality, 'the precise location of mortality pertaining to enteric disease is difficult to confirm.'[14] Harding has also observed that:

> No direct correlation of deaths from respiratory diseases and housing quality or topography can be made for most of the study period, though it may be significant that the proportion of consumption deaths declined in 1660, when causes of death in seven 'distant parishes (St. Margaret Westminster, Islington, Hackney, and Stepney in Middlesex, and Rotherhithe, Newington and Lambeth in Surrey) were added to the whole. Other things being equal, this suggests that respiratory ailments were worse in the crowded inner suburbs, and the greater distance from the centre was beneficial to health.[15]

Despite these limitations, it will be shown that the three methods of investigation offered by Champion still have currency for the present enquiry. Champion observed that although there are many qualitative references to the squalor or luxury of contemporary housing conditions, 'finding a source that expands such literary comment into a variable that might be applied with some accuracy across the whole city and for every household is less straightforward.'[16] To address this problem he suggested that the Hearth Taxes could be used to map housing conditions across the city because they focus upon the value of property.[17] In this regard Champion referred to the importance of Michael Power's analysis of the Hearth taxes assessed

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[13] Ibid. p.5.

[14] Harding, 'Housing and Health', p.37

[15] Ibid., p.39.

[16] Ibid. p.4.

[17] Ibid.

in London, Middlesex and Surrey before the Great Fire. [18] These taxes record the number of hearths per taxable household and provide a uniform factor with which to compare the experiences of different areas of London. Power drew attention to 'large assumptions' in using such data, however, particularly in terms of looking to the average number of hearths per dwelling in each parish to indicate the relative wealth of its inhabitants.[19] The first assumption addressed by Power was that a large number of hearths equals wealth and a small number poverty. He considered that this might seem crude but 'it is suggestive that the Acts which imposed the tax worked on this assumption.'[20] The second assumption is that everybody was included in the hearth tax, even the very poorest. Power provided examples of inconsistencies in the listing of the poor in different parishes and advised caution in interpreting the pattern of wealth in London based on this tax:

> The City [centre] parish data are derived from hearth taxes (1662 and 1666) which probably omit some poor; suburban parish data come from more comprehensive taxes (Ladyday and Michaelmas 1664) in which the poorest inhabitants seem more systematically listed. The average figures of hearths per dwelling in the City parishes will therefore be skewed upwards; those in the suburbs will probably be more correct.[21]

With these assumptions in mind, the Hearth Tax returns show that in the 1660s there were marked differences in the numbers of hearths per house in different parts of London. Champion considered it possible to map the variables pertaining to patterns of death and the quality of housing conditions and he has referred to sources such as William Faithorne's map of 1658 and the more detailed cartography of Ogilby and Morgan in the 1670s.[22] A critique of early modern cartography was made in Chapter 3 of this thesis and considered the Ogilby and Morgan map to be of great value despite the diagrammatic representation of yards and alleys. The map in figure 7.01 is a modern map, however, based on the one produced by Power. It shows that

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[18] Power 'The Social Topography'.

[19] Ibid. p.200.

[20] Ibid.

[21] Ibid, p.201; Guillery, *The Small House*, p.34 and also 'London's Suburbs, House Size and the Hearth Tax' in Barnwell and Airs (eds.), *Houses and the Hearth Tax*, pp.53-45.

[22] Ibid. p.2.

suburbs to the north, east and south, sweeping round from Clerkenwell clockwise through Shoreditch and Tower Hamlets across to Southwark, Bermondsey and Lambeth had mean dwelling sizes of four or fewer hearths. Suburbs to the west from Holborn anti-clockwise to Westminster, taking in St. Giles, all had mean dwelling sizes of four or more hearths. East London houses averaging 2.7 hearths were half the size of those of west London, averaging 5.5 hearths (though only 4.2 in St Margaret in Westminster); the city centre, however, was very mixed.

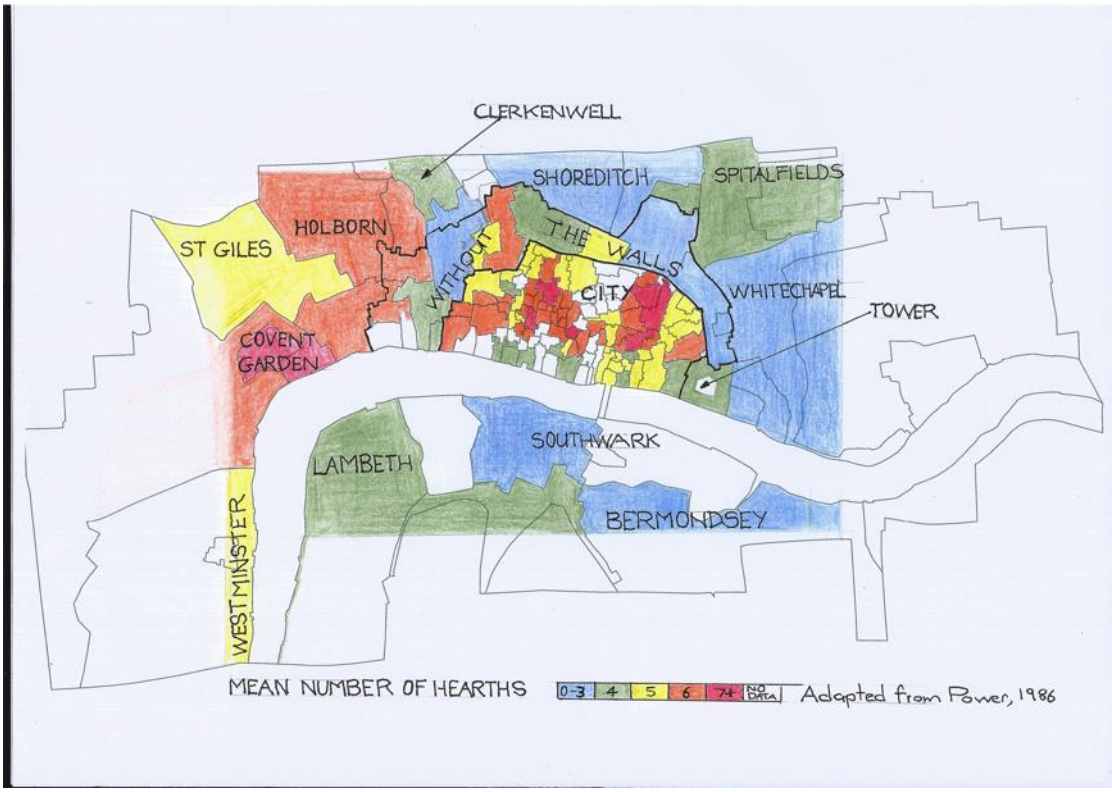

Figure 7.01 House size pertaining to Hearth Taxes. Drawn by S.M. Cornish

Power analysed this data in relation to social class, revealing an average house for skilled artisans had about four hearths, semi-skilled workers had closer to three, and professionals and merchants about six.[23] These findings are important building blocks in the construction of the social epidemiology of early modern London, but Champion stresses the importance of considering the 'real' conditions in such locations before discussing some of the patterns of mortality and the social structure

[23] Power, 'A social Topography, p.203 and also in 'East and West'.

revealed by mapping Hearth Tax data with the Bills of Mortality.[24] This leads the investigation to the first of his three methods.

7.2 The size and value of housing

Champion draws attention to past research into the historical reconstructions of physical house size 'that is studies that have explored the numbers of, sizes of, and even the contents of rooms [that] have enabled early modern historians to come to some general assessment and understanding of the dimensions of wealth and poverty in the early modern city.'[25] In Champion's view, however, it is 'a fair historical assumption that households that had only one or two hearths can be characterised as poor.'[26] He suggests that by supplementing this type of economic understanding it would be possible to contrive an historical investigation based upon a variety of other types of surviving sources and he cites archaeological material, combined with examinations of probate inventories to provide the physical and material structure of the early modern house. In this regard, Champion refers to some of the main sources used in this thesis, including *The London Surveys of Ralph Treswell* [27] and the work of Derek Keene and Vanessa Harding.[28]

Champion does offer another different but essentially 'complementary approach' by pursing other types of records that were concerned with the social management of poverty, illness and disease. He suggests that such sources might include Churchwardens' accounts books, records of the overseers of the poor, or listings of alms distributions which might, for example, give evidence about the number of households needing parish relief. Champion also draws attention to evidence to be found in the quarter sessions and other records that list landlords prosecuted for sub-dividing houses for rent to lodgers, inmates and migrants. From this he recognises that the combination of sources makes it possible to build up a picture of what types of household (conceived in a strictly economic, social and

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[24] Champion, 'Epidemics' p.4.

[25] Ibid.

[26] Ibid.

[27] Treswell, *The London Surveys*,

[28] Keene and Harding, *A survey of documentary Sources* and *Cheapside Gazetteer*.

material manner) were considered by contemporaries as marginal.[29] Champion concludes 'From this sort of confluence of sources that focus upon household it seems uncontentious to argue that ownership of hearths in some respects not only signified the physical quality of the living space but also related to the social-economic position of the resident household.'[30] As noted in Chapter 2, Landers has expressed mortality in social and economic terms as a function of conduction, retention and nutrition.'[31]

It has been argued in this thesis that the assumed high nutritional status of the wealthy could be compromised by constant exposure to unhealthy housing and the building pathology analysis has focused on the conduction and retention of enteric disease in terms of water supply and sanitation. Damp and cold buildings have been identified as a significant factor in the conduction and retention of respiratory complaints. The spread of airborne pathogens has been discussed in this thesis in terms of crowding into confined spaces. The Hearth Taxes do not specify the physical size of dwellings and as Champion suggests, other sources should be considered. This exercise was undertaken in detail in Chapter 4 where an analysis of four Pre-Fire house types identified by Schofield was made. The house types were based on floor plan and physical size. Schofield noted the pitfalls in relying solely on the number of hearths in describing the size of the dwelling, observing that the number of fireplaces in a house did not rise proportionately with the number of rooms;[32] this would have repercussions in terms of heating the buildings and is examined in more detail in Section 7.4 of this Chapter. In Chapter 4 it was noted that, with the odd exception, the relationship between the physical size of a dwelling and the spread of disease by overcrowding was not a widespread issue in the city.

There is some correlation of the socio-economic information provided by the Hearth Taxes with documentary sources on property holding and management. High land values in the 97 parishes within the walls, together with constraints on space and

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[29] Champion, 'Epidemics' p.4.

[30] Ibid.

[31] Landers, *Death and the Metropolis*, p.13.

[32] Schofield, *The Building of London*, pp.159-60.

the demand for accommodation close to the city centre encouraged the development of better-built, taller houses.[33] As has been discussed in the building pathology analysis, these dwellings in the city centre shared the same building practices and materials as those in the immediate extramural suburbs (comprising 16 parishes) and the outer suburbs including Westminster. What varied were the size and 'spatial disposition' of properties;[34] this thesis has also observed the variations in the quality of materials and building services available. Thus, although it would appear self-evident that economic factors would have had an influence in the quality of housing, the building pathology analysis has found that this was in relative rather than absolute terms.

Chapters 5 and 6 have shown that the wealthy city centre landlords had an interest in maintaining the quality of their premises in order to command high rents. This was pursued through capital investment or ensuring that their tenants complied with repairing covenants. Evidence included in property holding and management records as well as the reports of the Viewers have shown, however, that maintenance was undertaken on a 'corrective' rather than a 'preventative' basis. This thesis has revealed that the defects had already occurred in properties belonging to the wealthy and middling sort through a failure in building components. Many cases have been given in the building pathology analysis, for example defective roof tiles. It was noted in Chapter 5 that there was contemporary knowledge of the life span of certain building components such as clay roof tiles. Rather than replacing roof tiles in anticipation of them reaching the end of their life, however, the failure occurred and the contemporary records have often shown that the defect had often taken place for some time before remedial action was taken.

Although the failure to undertake planned preventative maintenance remains a problem in the twenty first century, consideration still needs to be given to long-term exposure to insanitary, cold and damp dwellings across a wider social and economic spectrum of early modern London. As noted in Chapter 2 Landers considered that mortality over time could be expressed as a function of 'conduction, pathogen load,

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[33] Harding 'Housing and Health' p.25.

[34] Ibid.

nutritional and immunological status.'[35] Landers expressed this formula in the context of contagious diseases in the built environment. The building pathology analysis has enabled Landers' model of 'mortality over time' to be extended to include the effects of non-pathogenic complaints induced by cold and damp housing conditions. Given that the wealthy were also exposed to unhealthy buildings, we must ask whether there is some correlation with the findings of Peter Razzell and Christine Spence referred to in Chapter 2. It was noted that they raised fundamental questions about the role of poverty and social class in shaping mortality in London during the study period, as there appears to have been a minimum social gradient in infant, child, and adult deaths.[36] This echoes the findings of some modern epidemiologists also noted in Chapter 2, where on occasions social class may be considered an embarrassment to epidemiology.[37] Razzell and Spence do not specify specific diseases in their study of mortality but the building pathology analysis suggests that the long-term exposure of all socio-economic groups to unhealthy housing was 'real.'

Thus, the size and value of housing are two important variables to consider in the context of building-related illnesses but unlike Champion's study of the plague, these variables do not fully determine the potential exposure to enteric and respiratory complaints. Another form of classifying housing is therefore required which would enable an assessment of the 'exposure potential'; this was defined in Chapter 2 as a function of conduction, retention and bounding.[38] The conduction and retention of illnesses in timber and brick built buildings have been discussed in some detail in the building pathology analysis but the inclusion of 'bounding' in the exposure potential formula requires consideration of locality. As the 'Contextual Model of Buildings' illustrated in the opening Chapter, construction-type cannot be considered in isolation; buildings interact with the external environment. The next section of this Chapter will therefore investigate the buildings in certain locations in early modern London.

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[35] Landers, *Death and the Metropolis*, pp.35-36.

[36] Razzell and Spence, 'The History of Mortality' p.271.

[37] Jones and Cameron, 'Social Class' pp. 44-50.

[38] Landers, *Death and the Metropolis*, p.38.

7.3 Variations between distinct localities

John Stow observed significant variations between Aldermanbury and Aldgate, even though they were less than a mile apart. He noted the former comprised 'divers fair houses' whereas the latter was composed of 'filthy cottages.'[39] Such wide variations in the physical environment of London may account for local variations in enteric and respiratory diseases. According to *People in Place* deaths are partly determined by local factors.[40] This section of the Chapter will consider neighbourhood characteristics in terms of the physical presence of buildings in streets, lanes, yards and alleys, and also various water supplies and sanitation. In order to be of value to this social epidemiology study these local characteristics must be considered alongside the various socio-economic groups.

A broad social topography of the city was given in the opening Chapter largely based on Power's analysis of the hearth taxes.[41] It was noted in Chapter 1 that commercial interests influenced the location of occupations.[42] Power considered the link between wealth and occupation, and discussed which of these most influenced location. He suggests that there is an argument that they were both strong determinants both at street and parish level but within the city walls 'the hearth tax demonstrates that the tradition of occupational clustering was still very much alive in 1666'.[43] In the city centre the wealthier selling groups such as dealers and victuallers monopolized the relatively wide streets, whereas the poorer craftsmen and semi-skilled workers occupied the lanes, yards and alleys, all of which would be in the same parish. Power estimated that within the city centre perhaps one third of the inhabitants had a street address; about a third more occupied dwellings along the lanes; and the remaining third dwelled in yards and alleys.[44]

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[39] Stow, *A Survey*, pp. 282 and 384.

[40] Harding *et al*, *People in Place*, p.28.

[41] Power 'The Social Topography'.

[42] Ibid. p.213.

[43] Ibid. 221.

[44] Power 'The Social Topography', p.209.

The Hearth Taxes suggest that these four types of addresses had distinct physical characteristics and these will now be compared in the context of the width of thoroughfares and building heights. Such factors would have influenced the quality of daylight and ventilation in and around the dwellings. A street was major thoroughfare, wide and often paved. A scaled dimension from Ogilby and Morgan's map of Cheapside at the junction of Friday reveals a width of approximately 60 feet.

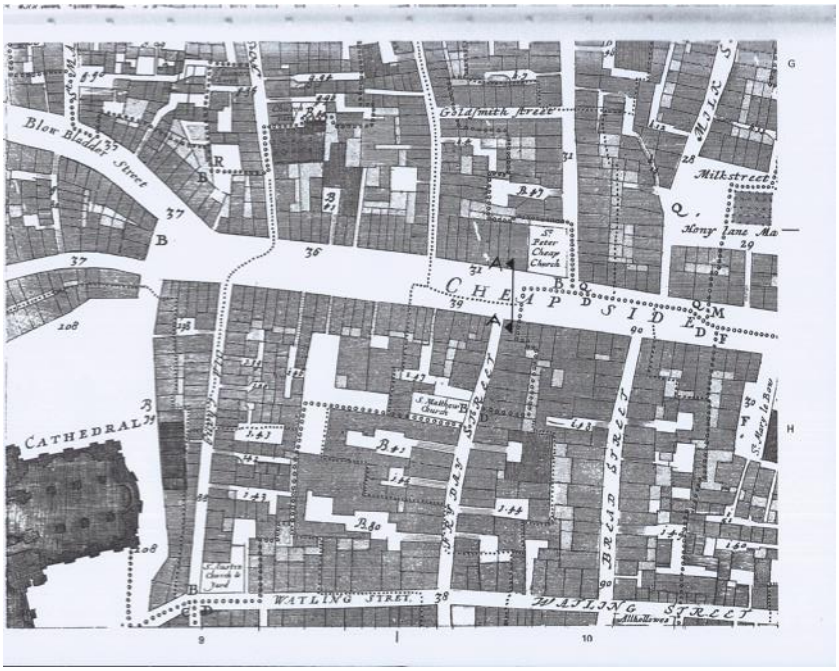

Figure 7.02 –The western end of Cheapside, from Ogilby and Morgan in Hyde, *The A-Z of Restoration London*, p.25.

Pre-Fire buildings fronting this major street were as high as 60 feet.[45] The Rebuilding Act of 1667 specified that 'buildings fronting the high and principall Streetes shall consist of four Stories high besides Cellars and Garrets […] that the first Story containe full ten foote in height from the Floore to the Cielling, the second ten foote and an halfe, the third nine foote, the fourth eight foote and an halfe…'[46] This produced a net height of 38 feet (excluding floor thicknesses and the roof structure). At 37 Cheapside stood the post-Fire building called the 'Chained Swan', a brick house on the east corner of Friday Street. The elevation drawn by

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[45] Harding *et al*, *People in Place*, p.6; Keene, 'Tall Buildings', p.202.

[46] *Statues of the Realm* pp.603-612. Date Accessed: 30 November 2013.

Baker is to a scale of 1: 1250 and suggests this building, of four storeys plus a garret, was approximately 47 feet high.[47] Figure 7.03 shows an approximate sectional drawing through this building at section at A-A taken from figure 7.02.

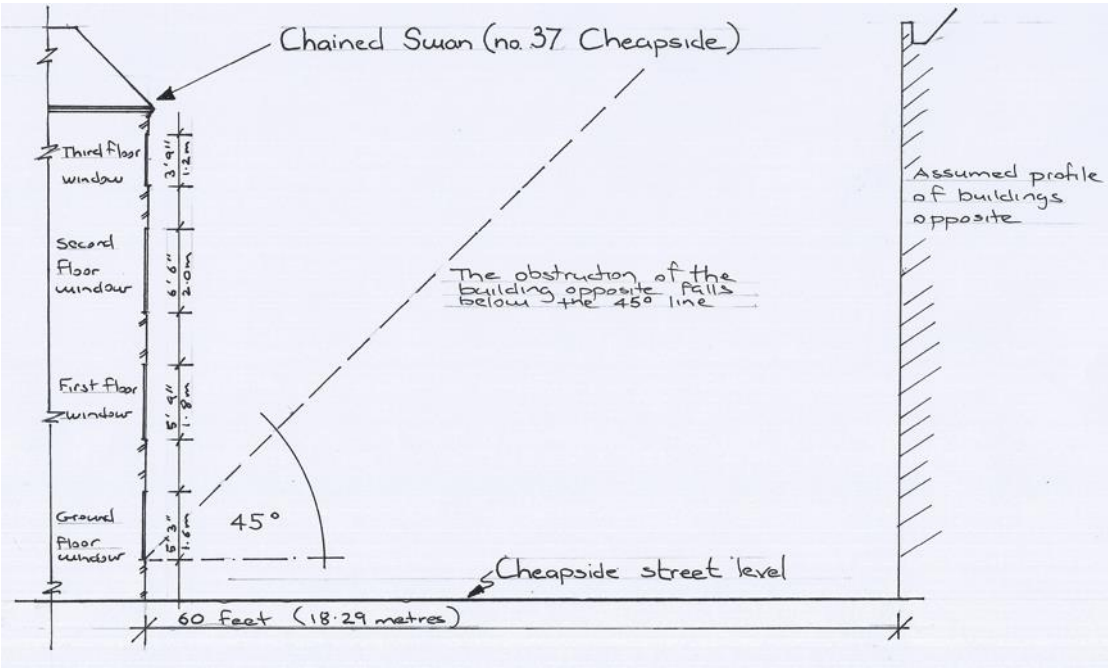

Figure 7.03 - A section through Cheapside taken at A-A on figure 7.02, drawn by S.M. Cornish

This illustrates the provision of good natural lighting to such buildings, based on one method of the measurement of light used in the modern era[48] which has been identified in Chapters 4 and 6 as crucial in restricting the spread of pathogens, destroying certain bacteria and providing a heating effect once it penetrates through glazed windows. This method of measuring light has been criticised, however, because it ignores completely the layout of the room.[49] Even without the benefit of gaining access within early modern buildings in Cheapside, it is certain that the amount of light reaching the rooms, at least at the front of the building, would have met modern criteria. As well as receiving natural light, good ventilation would have been possible around the buildings, providing an opportunity for a healthful number of air changes within the dwellings.

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[47] Baker, *London: rebuilding the City*, p.56.

[48] John Anstey, *Rights of Light* (RICS Books, 2002), pp.55-65.

[49] Ibid. pp.58-9.

Consideration should be given, however, to the impact these taller buildings in the main streets would have had on nearby dwellings in the other kinds of addresses identified by Power, that is the narrow lanes, confined yards (or courts) and alleys, Two of the buildings included in the Audits were located in lanes. The first building is 3-4 St. Pancras Lane (Audit A), which was located on the south side of this public thoroughfare, opposite the church of St. Pancras. The pre-Fire building comprised two storeys plus a garret, facing a lane that appears to be no more than 16 feet wide at this point. The height of the church opposite is not certain but would have had an impact on light entering the building, particularly at ground floor level. Following the Great Fire, houses in lanes were restricted to 'three Stories high beside Cellars and Garrets […] that the first Story containe full tenn foote in height from the Floore to the Sieling the second full ten foote, the third nine foote…'[50] Amen Court (Audit D) was built to this statutory requirement, on the north side of a lane some 16 feet wide. Properties on the opposite of this lane are of a similar height. The rooms up to first floor level would not have received the amount of light to meet the modern criteria; it is only at garret level where adequate light would have been received into the rooms.

Although a lane was generally a narrow thoroughfare it possibly received more natural light and ventilation than a yard or court, which was an enclosed space, entered from a turning off the street or lane; an alley was a very narrow way between buildings. As noted in Chapter 6, there are pre-Fire examples of the wealthy living in 'court houses'. Some of these are illustrated in Treswell's surveys and Power has identified titled people living in such locations, for example Half Moon Court in St Botolph, Aldersgate.[51] The Rebuilding Act does not mention yards, courts, or alleys. It may be that houses in such confined locations were expected to meet the same requirements as those 'Houses of the first and least sort' that were to front 'By streetes or Lanes'. These buildings were to be 'two Stories high besides Cellers and Garrets…' The ground floor or 'first Story' was to be 'nine foote high from the Floore to the Cieling, and the second Story nine foote high from the Floore to the

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[50] *Statutes of the Realm*, pp.603-12, section vii.

[51] Treswell, *London Surveys*, pp. 76-7 and 101; Power 'The social Topography', p.209.

Ceiling.'[52] Power has used these dimensions to estimate the height of houses in pre-Fire Lime Street, in Shadwell. In the case of the East End suburbs, the designation of a thoroughfare as a street does not signify the same environmental standards as those associated with the city centre. Power has estimated the width of Lime Street in Shadwell was 15 feet. He has concluded that separated from their neighbours by such narrow streets meant that little daylight could have penetrated into the rooms of these dwellings, even though the buildings were only two storeys high.[53]

Variations in widths of streets, lanes, yards and alleys, together with building heights indicate a progressive decline in the provision of daylight and ventilation in the city centre. These were important factors pertaining to variations in enteric and respiratory illnesses across the city, however, a survey of the distribution of essential services is now required. Different forms of water supply may provide some clues to variations in enteric disease in distinct localities. As noted in Chapter 4, one of the five main conditions required to prevent enteric disease is a safe, adequate, potable and palatable water supply that is available to each dwelling under pressure. It has already been noted that the city centre in early modern London was fairly well supplied with conduits, bosses, and wells and pumps, and the New River.

Consideration is now required of the modern epidemiological evidence that suggests different modes of water supply can produce wide-ranging fluctuations in enteric diseases within a relatively small area. These studies undertaken in the United States of America in the 1950s still have currency in the modern era in England.[54] The studies are relevant in that they have found variations in enteric disease associated with water supplies even where the water has not been the subject of the filtration and chlorination processes described in Chapter 4. Epidemiological studies conducted in migratory labour camps in California showed that the infection rate of Shigella[55] in children of ten years of age and under who live in dwellings with no inside water supply was approximately twice the rate which was observed in children

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[52] *Statutes of the Realm*, pp.603-12, section viii.

[53] Power 'East London Housing' p. 254.

[54] Mood, 'Fundamentals of Healthful Housing' p.307.

[55] Shigella is a dysentery-causing bacterium: a rod-shaped bacterium that lives in the intestinal tracts of human beings and animals and causes dysentery.

of the same age whose home has an inside water supply and which was provided under pressure.[56] It was noted in Chapter 4 that although the New River was supplying piped water supplies into houses, under pressure, from the early seventeenth century, it did not become a major source until later into the study period; in 1618 the number of tenants only just exceeded 1,000.'[57] Included among those properties being supplied were 3-4 St. Pancras Lane (Audit A) and 3 Amen Court (Audit D) confirming that this form of supply was limited to the wealthier areas. Piped supplies were also laid onto a number of high-class West End developments but there were anomalies for, as already noted, despite the intention to attract high-status tenants, the original licence for the development of Covent Garden made no provision for water supply. Unusually for eastern suburbs there was a pumped water supply after 1680 to Shadwell; it is not clear how many individual houses benefitted.[58]

We have seen that private wells were still in use in the city centre in the study period, including 16 Cornhill (Audit B). Modern epidemiological studies provide food for thought as to whether this was a more healthful water supply than collecting water from public wells, conduits and rivers. In a series of studies conducted in Georgia, USA, in the 1950s, Shigella infections were about one and a half times more frequent among those persons who resided in dwellings which did not have a source of drinking water on the same premises as the dwelling, compared with persons who resided in dwellings without an inside pipe water supply but who had a source of water on the premises.[59] The outer suburbs of early modern London may in general have had relatively good access to decent water supplies, in the streams and water courses flowing towards the city, but the inner suburbs had neither, and modern

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[56] A.C. Hollister, *et al*, "Influence of water availability on Shigella prevalence in children of farm labour families' in the *American Journal of Public Health*, 1955, pp.45, 354-62, quoted in Mood 'Fundamentals of Healthful Housing' p.307

[57] Gough, *Middleton*, p.66.

[58] Harding, 'Housing and Health', p.36.

[59] Stewart *et al*, 'Diarrhoeal disease control studies. IV The Relationship of certain environmental factors to the prevalence of Shigella infection' in the *American Journal of Tropical Medicine and Hygiene*, 1955, pp. 4, 718-24, quoted in Mood, 'Fundamentals of Healthful Housing' p.307.

epidemiological studies suggest that this would have placed the population of the latter at great risk. The prevalence rate for Shigella, the incidence of Ascaris[60] infections, and morbidity from diarrhoeal diseases are associated in an inverse manner with the availability of water.[61] The lowest rates were found among persons who resided in dwellings which had a water supply piped inside the dwelling and the highest rates were among those whose source of water was off the premises.[62]

It is possible that the water bearers of early modern London served the population of the inner suburbs,[63] but they would have brought the water from relatively remote sources. Studies conducted by the WHO Diarrhoeal Disease Team in Venezuela in the 1960s demonstrated that the further the water source is from the premises, the greater the number of cases of diarrhoeal disease.[64] Applying such data to early modern London is significant because the majority of Londoners still collected water from the public conduits or watercourses including the Thames, or bought it from street sellers who obtained it from the same source. It was noted in Chapter 6 that many of the residents of pre-Fire Eastcheap, including the artisan Wallington, relied on the latter source even though they were close to the works pumping Thames water from London Bridge. Thames water was an important source for riverside parishes but as noted in Chapter 4, it was also used as a foul-water sewer. If waterside location was a significant adverse variable for infant mortality

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[60] Ascaris is a genus of parasitic worm in the nematode phylum. The most widely known is the common intestinal roundworm.

[61] D.J. Schliessman *et al*, 'Relation of Environmental Factors to the Occurrence of Enteric Diseases in Areas of Eastern Kentucky in the *Public Health Monograph No.54* (US Government, Printing Office, Washington, D.C. 1958); D.J. Schliessman, 'Diarrhoeal disease and the environment' in *Bulletin, World Health Organisation* pp.21 and 381-6; also in Mood, 'The Fundamentals of Healthful Housing' p. 307.

[62] Ibid.

[63] Harding, 'Housing and Health' p.36.

[64] H.L.Wolff *et al*, 'Houseflies, the availability of water, and diarrheal disease, *Bulletin WHO*, 1969, pp.41, and 951-9.

rates, as identified by Finlay, this presumably had implications for child and adult health.[65]

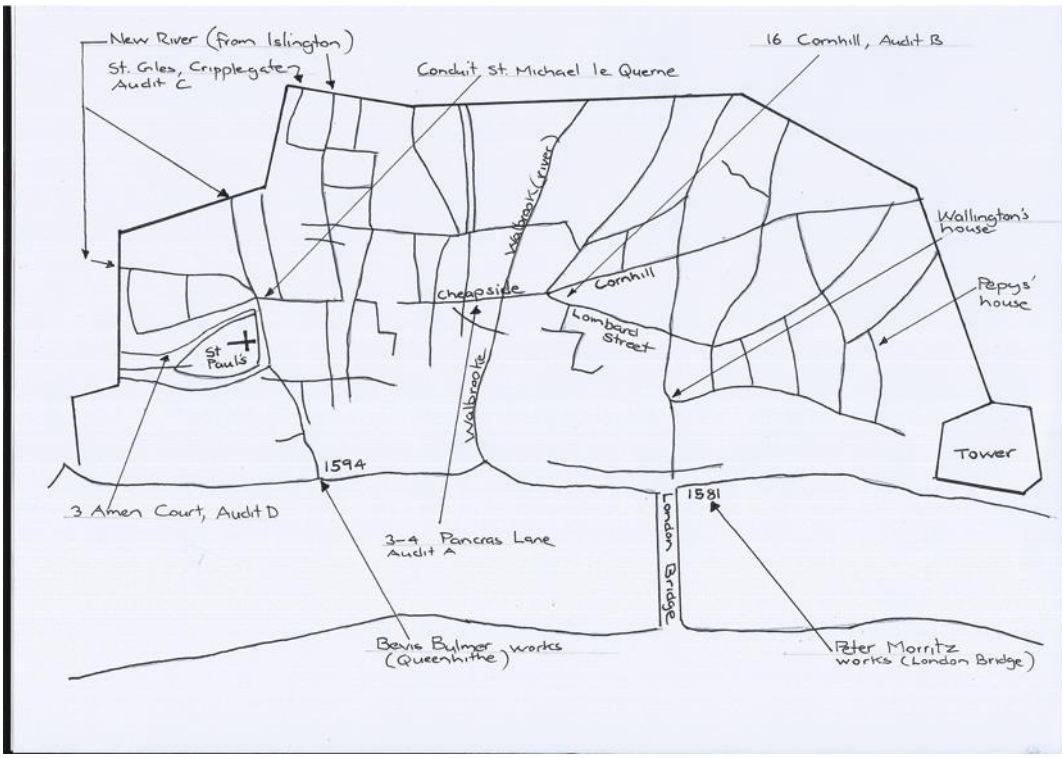

Figure 7.04 Water supplies to the city centre 1581-1630, adapted from Weinstein, 'New urban demands in early modern London' p.37. Drawn by S.M. Cornish.

The above map (figure 7.04) illustrates water supplies to the city centre 1581-1630, and could be useful in 'mapping' areas of relative risk in contracting enteric disease based on the type of water supply. Based on the above modern epidemiological findings, the population of the riverside parishes would have been at the greatest risk to the conduction pathogens, followed by the inner suburbs.

The analysis in Chapters 4 and 6 of this thesis has demonstrated that the collection and the disposal of excrement was a major issue throughout the city and was very much dependent upon the vigilance of the users of a building. Despite evidence of sanitary systems flushed by water in Greek and Roman civilisations and a water closet designed in Elizabethan times,[66] it would be unrealistic to consider flushing toilets to have been an expectation of the population in the early modern

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[65] Finlay, *Population and Metropolis*, p.103.

[66] Marshal and Worthing, *The Construction of Houses*, p.27.

period. It was not until the nineteenth century that a significant association between types of toilets serving an urban population and cases of typhoid fever was made by Dr. Boobbyer.[67] It would clearly be a hypothetical exercise to compare the relative performance of privies with flushing toilets in the context of early modern London but Boobbyer's exhaustive study carried out between 1886-96 of the epidemiology of typhoid fever in Nottingham provides some useful information on the health risk posed by privies. He observed that the case incidence ratio of persons residing in dwellings served by a privy was one in thirty-seven, while the case incidence ratio of persons residing in dwellings with indoor flush water closets was only one in 558.[68]

Data collected in 1935 and 1936 during the National Health Survey in the USA showed excessive incidence of typhoid fever and paratyphoid fevers, diarrhoea, enteritis and colitis among persons among persons living in housing lacking a private inside flush system.[69] In another investigation that was published in 1935, it was demonstrated that the prevalence of typhoid fever (and infant mortality) was significantly higher in those neighbourhoods in Memphis, Tennessee, in which there was a preponderance of houses lacking indoor flush toilets. In research undertaken in 1951 by the US Public Health Service of enteric disease among residents of several eastern Kentucky mining towns, it was observed that persons living in dwellings which utilised privies as the means of excreta disposal experienced approximately twice as many cases of diarrhoeal diseases as persons residing in houses with inside flush toilets. Shigella infections in children under ten years of age and rates of morbidity from diarrhoeal disease were particularly high. Although the provision of indoor flush toilets could not have been met in early modern London, these modern studies do show that the location of privies near or within a dwelling represented a high risk to the conduction and retention of pathogens. It is the wealthier city centre of early modern London, however, where the 'exposure potential' would have been greatest, because we have seen in Chapters 4 and 6 that privies were typically located

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[67] Mood, 'Fundamentals of Healthful Housing', p.308.

[68] Ibid.

[69] Ibid.

close to or within dwellings. 'Bounding' or stressed induced migration into areas of the city centre and inner suburbs would have exacerbated the problem.

Other variables were noted in Chapter 4 including sanitary collection, storage and disposal of refuse and other solid wastes; prevention of access into dwelling units of insect vectors of human disease; freedom within the dwelling from rodents, vermin and other than animals; sanitary provision for the proper storage of milk and other food stuffs. [70] Street markets were relocated following the Great Fire, which may have reduced refuse and solid waste, and the number of rodents and vermin near the dwellings, but this is conjecture. As the precise location of mortality through enteric disease is difficult to establish, the above analysis would suggest that in relative terms the wealthy had less exposure to enteric diseases emanating from their water supplies but were at greater risk than the poor to those diseases associated with the location of their privies. A conundrum has been posed in this analysis: 'if a high level enteric mortality seems a predictable concomitant of poor water supply and sanitation, the surprise is rather in the apparent improvement in the later seventeenth century despite London's continued growth.'[71] The building pathology analysis has shown that the potential for the 'conduction' of pathogens remained high throughout the study period. Chapters 4 and 6 have not revealed any substantial improvements in the quality of water supply, other than the numbers of the population using the New River increasing slightly towards the end of the study period. This suggests that this investigation should look beyond the first two methods put forward by Champion.

7.4 Seasonality and the effects on housing and health

Reference was made earlier to mortality over time and this section of the Chapter considers the season as a method of measurement. In her study of south-east England Dobson observed that burials peaked in the late winter and spring months, while overall the summer season clearly remained the least mortal time of the year.[72] Dobson refers to the work of Ronald Lee who found that high summer temperatures

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[70] Mood, 'Fundamentals of Healthful Housing', p.306.

[71] Harding, 'Housing and Health', p.37.

[72] Dobson, *Contours of Death*, p.203.

exerted a greater influence on mortality fluctuations than cold temperatures.[73] She notes that Lee's statistical analysis also revealed that the effect of cold temperatures had an immediate impact on the mortality statistics of the same month while the effect of a rise in summer temperature was delayed by one or two months. Conversely, a one degree centigrade warming of winter reduced annual mortality by about 2 per cent while a one degree centigrade cooling of summer would reduce mortality by about 4 per cent. Lee estimates that these changes would raise period life expectancy by about two years. He also considers that annual rainfall showed little relationship with annual mortality fluctuations.[74] According to Dobson, however, these aggregate regional and national patterns mask some very interesting local deviations: 'Different environments and localities of south-east England responded in varying ways to annual and seasonal vicissitudes of temperature and rainfall.'[75] Landers confirmed this in his analysis of the seasonality of mortality in the context of early modern London, particularly in his account of the dramatic disappearance of excess summer mortality by 1830.[76]

Although excess summer mortality had been a significant feature of seventeenth-century data, Finlay's analysis of six London burial registers suggests that this excess was established as early as the sixteenth century.[77] Landers considers that 'the elimination of the summer burial peaks in the years after 1700 suggests the amelioration of some old form of gastric disease […] as the seventeenth century gave way to the eighteenth.'[78] As noted earlier, the building pathology analysis has not identified any significant improvement in the capital's physical environment to account for this phenomenon and Harding has noted this anomaly despite London's continued growth.[79] Landers considers that the reasons were 'exogenous to economy

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[73] Lee in Wrigley and Schofield, *The Population History*, p.389, quoted in Dobson, *Contours of Death*, p.203.

[74] Ibid.

[75] Dobson, *Contours of Death*, p.209.

[76] Landers, *Death and the Metropolis*, pp.238-9.

[77] Finlay, *Population and the Metropolis*, p.138.

[78] Landers, *Death and the Metropolis*, p.239.

[79] Harding, 'Housing and Health', p.37.

and society' and he offers two possibilities.[80] The first is climate. He refers to gastric complaint being more virulent during the late summer and early autumn in temperate latitudes, since the higher temperatures of mid-summer apparently impede its spread. As noted in Chapter 6, the early and middle part of the study period was experiencing the 'Little Ice Age' and mean August temperatures were a full degree lower than in the last quarter of the seventeenth century than the first quarter of the eighteenth. Based on this evidence Landers suggest that the unusually cool summers of this period allowed enteric complaints to become established much earlier in the season than was to be the case as temperatures rose again after 1700.[81] The second possibility put forward by Landers does not exclude the first, but is more to do with a change in the nature of the pathogen. It is possible that the strain of the disease was more infective but less severe later in the eighteenth century.[82]

Thus, the climate for most of the study period was conducive to the spread of enteric pathogens through the water supplies and from privies close to or within dwellings. Thus, it has been argued in the building pathology analysis that housing was a significant part of the casual system of enteric disease; a similar case has been made with regard to respiratory complaints. The substantial rise in winter mortality in the early part of the study period has led Landers to suggest that this was related in part to a significant increase in 'respiratory conditions' that continued after 1700.[83] As described in Chapter 6, as the sixteenth century wore on summers were short and wet and winters were savage. Great demands were therefore placed on the performance of housing to provide dry and warm shelter. It has been suggested in Chapter 5 that the analysis of 'construction-type' may assist in determining possible variations in respiratory complaints across a range of socio-economic groups over time and place.

Razzell is of the opinion that the rebuilding of houses in brick and tile went some way to reducing the spread of pathogens. According to him a 'revolution in

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[80] Ibid.

[81] Ibid.

[82] Ibid.

[83] Ibid.

domestic hygiene' took place with the hard and relatively smooth surfaces of bricks and tiles lending themselves to be more easily washed and scrubbed in contrast to timber frames with earthen floors.[84] The building pathology analysis has extended the investigation by drawing comparisons between the relative function and performance of timber-frame and brick-built dwellings with regard to thermal insulation and damp proofing. It has been noted in Chapter 5 that the brick-built buildings had only slightly better thermal insulation qualities than timber-framed buildings and the results of this investigation are summarised in the Building Audits in Appendix A. Thus, the superior thermal insulation qualities of brick-built dwellings over timber-framed structures can only be considered in relative terms. The brick-built houses of the wealthy in the West End and the rebuilt city centre were still subject to significant heat-loss. The possible response by the occupants in heating the buildings must be considered.

Reference to figure 7.01 would suggest that we might map the warm houses across London with some ease based on the number of hearths. As noted earlier, however, Schofield's analysis of dwellings prior to the Great Fire suggests that the number of fireplaces in a house did not rise proportionately with the number of rooms. He has compared the heating provisions of three different types of houses in the city centre in the early seventeenth century. The smallest of these dwellings was located in Billiter Lane (now Billiter Street) and was occupied by Widow Kinricke. This dwelling had only one room on each of the three floors. The second and third dwelling types were located nearby in Fenchurch Street and were in the same block of buildings. The second type was a two-room plan house and the accommodation was spread over four floors and occupied by William Jennynges. The third and largest of the houses was occupied by Jacques de Bees, whose dwelling comprised ten rooms spread over three floors. Potentially, Widow Kinricke could heat two of her three rooms, or 66 per cent of her accommodation, whereas William Jennynges could only heat three out of seven rooms, (43 per cent) and Jacques de Bees 40 per cent.[85]

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[84] Peter Razzell, 'The Growth of Population in Eighteenth Century in Eighteenth-Century England: A Critical Appraisal' in *The Journal of Economic History* (Cambridge University Press, 1993), p.768.

[85] Schofield, *The Building of London*, pp.159-60.

A study of the properties included in the Building Audits makes for an interesting comparison with Schofield's analysis. One of the two tenancies in 4-6 St. Pancras Lane (Audit A) had twelve rooms plus four garrets but only four hearths are specified, thus only 33 per cent of the accommodation was heated. The compact building 16 Cornhill (Audit B) comprised 15 rooms (including the shop, warehouse and three garrets), and six hearths are specified, potentially heating 40 per cent of the accommodation. Audit C provides details of the generic shed structure, and as noted in the 'building pathology analysis' some of these buildings comprised one or two living spaces, along with a single hearth; 50-100 per cent of the building was heated. The post-Fire House at 3 Amen Court (Audit D) was built to a high standard, with four rooms on each of the four floors (including the cellar and garret) and with 12 hearths; 75 per cent of the accommodation was heated. With the exception of Amen Court, the study of the Building Audits tends to reinforce the findings of Schofield. Although there was potential to heat a greater proportion of the living accommodation in smaller houses, this does not necessarily identity the warmer houses. The pattern of use in the context of relatively inefficient open fires and poor thermal insulation of the building fabric requires discussion.

As noted in Chapter 4, modern studies suggest where there is an inadequate heating system, it is usual for all members of the household to congregate in one 'heatable space,' often the living room.[86] In one-hearth dwellings this is inevitable, but in houses with two or more hearths this behavioural pattern could be dictated by the poor performance of the heating system as much as the wealth of the occupants. A counter-argument to consider here, however, is the modern behavioural pattern of congregating in one 'heatable' space does not hold in the context of the wealthy, living in early modern London. Margaret Spufford argued that wealthier members of society could afford to construct more hearths in their dwellings, made possible by the switch from timber chimneys to brick. She has considered the reasons behind the increase in the number of hearths, noting that in the late seventeenth century, upstairs rooms either came to be used as bedrooms for the first time, and higher standards of comfort in general was demanded. There was also the possibility of a genuine

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[86] Thomas Markus, 'Cold, condensation and housing poverty'p.146.

requirement for more warmth in dwellings through more hearths during the 'Little Ice Age'.[87]

As the thermal capacity of early modern houses was low, it would take a considerable amount of heat over a protracted period of time to provide a surface temperature to the walls capable of resisting the build-up of condensation and general dampness. As noted in Chapter 6, the contemporary Robert Clavering advocated long periods of heating to counteract such problems.[88] The preceding Chapter also discussed how this would have been made possible by the increase in the supply of sea coal. Although there are no figures available for the 1660s, coal was already being imported into London in large quantities before the Great Fire, and this became the keystone for the rebuilding of the city. A tax had to be raised to finance reconstruction. Reddaway noted that '£100,000 was required, and required within five years at the furthest.'[89] An indirect tax was imposed on coal entering the port of London which by the 1680s had reached 350,000 tons per annum.[90] The increase in the number of hearths could, however, be affected by the availability and cost of different kinds of fuel, the history of which has yet to be systematically studied.[91] As noted in the last Chapter, Spufford has observed that very little work has been done on the type of fuel consumed, despite some probate inventories describing the contents of people's woodsheds and yards.[92] Despite the increase in consumption of coal it would seem that it was still beyond the economic means of many. 'Hedge breaking' in rural areas was 'a particular misdemeanour of the poor' where they were searching the hedges for fuel.[93] From the beginning of the sixteenth century the prosperous were making provision in their wills for the distribution of coal to the

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[87] Spufford, 'Chimneys, Wood and Coal' p.24.

[88] Clavering, *An Essay*, p.67

[89] Reddaway, *The Rebuilding of London*, p.85.

[90] Ibid.

[91] Barnwell, 'Houses, Hearths and Historical Inquiry' in Barnwell and Airs (eds.) *Houses and the Hearth Tax*, p.177.

[92] Spufford, 'Chimneys, Wood and Coal', p.25.

[93] Ibid. p.30.

poor in London.[94] In the last Chapter it was noted that the occupants of a shed in post-Fire London were burning wood shavings. On the assumption raised by Power, that a large number of hearths equals wealth and a small number poverty, warm houses may be class-specific. Whether this reduced respiratory illness requires consideration of an 'exogenous' factor.

If a greater number of fireplaces were used simultaneously, then this would have exacerbated another localised environmental issue: smoke pollution. The difficulty of a 'confounder' as a factor in the study of respiratory illnesses was identified in Chapter 2. In this case the confounder is the quality of heating that would have influenced both exposure to the hazard of cold temperatures and (independently) the likelihood of an adverse health event through the increased burning of sea coal; the latter may well have exerted an independent effect on respiratory function.

The building pathology analysis has highlighted the importance of heating a building to prevent the development of condensation and mould to the interior which may also lead to respiratory complaints. Condensation is just one form of potential dampness in the buildings of early modern London. As shown in the building pathology analysis dampness can reduce the thermal insulation performance of the building fabric. The class specific factor of superior materials and higher standards of heating may have been nullified by the presence of dampness. The analysis has shown the potential for dampness being widespread in most types of buildings occupied by different socio-economic classes, a factor no doubt compounded by the exceptionally wet summers as well as winters during the study period and the lack of effective maintenance to inherently vulnerable buildings.

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[94] Ibid. p.28.

7.6 Conclusion

The study of enteric and respiratory complaints in the context of social epidemiology has produced a conundrum. The Bills of Mortality and other contemporary sources have confirmed that these two diseases were widespread and relatively constant killers in early modern London and yet locating them within communities, spatially and residentially defined has proved problematic. The methodology put forward by Champion has proved useful, despite recognising that it is easier to relate plague deaths to places in early modern London than it is for enteric and respiratory diseases.

The socio-economic analysis of the Hearth Taxes provides a valuable reference point in terms of considering the location of various social groups and the assumed quality of their housing. Supplementing this data are the records of property holding and management which confirms that the wealthy had greater resources to maintain and improve their properties, and access to a larger number of fireplaces for warmth. The study of water distribution in the city also provides an opportunity to map social topography and identifying the location of different sources and quality of supplies. All things being equal, the streets and certain lanes within the city centre, together with large brick-built West End developments would appear to have been relatively healthy environments. The reports of the City's Viewers and Surveyors have, however, identified conditions that were conducive to the spread of enteric and respiratory diseases amongst the wealthy as well as the poor. Although the findings of the Viewers and Surveyors have been the main source in reaching this conclusion, this could not have been fully achieved without reference to the other sources discussed in Chapter 3. Applying the source material to the analytical framework of modern *building pathology* has been of great value in identifying defects in the buildings of early modern London of all socio-economic groups. Not only has it been possible to consider failings in building practice, policy and maintenance but also inherent defects in the buildings and their services.

The 'Contextual Model of Buildings' is the kernel of *building pathology* and draws attention to the interaction of the external environment with buildings; the climate of the study period imposed extreme demands on the dwellings and their services. These demands, in the words of Landers, were largely 'exogenous to economy and society.' Social epidemiology recognises causal systems, and unhealthy housing was a large part of the system. The buildings of the study period provided the

‘pathway’ for the spread of enteric pathogens and heat loss from and dampness into the dwellings. It was the extremes of the climate of the study period that encouraged the virulence of the pathogens, and produced very damp and cold conditions. This thesis has sought to avoid the temptation to search for any single determinant of mortality patterns and their changes over time and space but through the application of *building pathology* it has been demonstrated that housing would have played an important part in the environmental determination of enteric and respiratory illnesses.

Chapter 8
Conclusions and Future Directions

As noted in Chapter 1, the close correlation of housing and health outcomes in early modern London is problematic but 'there are certainly connections to be inferred.'[1] Enteric and respiratory diseases are closely associated with the urban environment, especially domestic housing.[2] The statistics quoted in Chapter 1 confirmed that these particular diseases killed significant numbers in London during the study period and it was for this reason that the scope of the main question was refined to exploring the influence of housing, building policies and practice in the propagation of these two specific diseases. It has been acknowledged in the opening Chapter that other diseases may be associated with the built environment but it is beyond the scope of a single thesis to consider these in any detail and further direction is given later in this Chapter.

Consideration of the influence of defective buildings on health has also been made in terms of fluctuations in the diseases, particularly in view of the fact that enteric complaints declined by 1700, despite the growth of the capital, and that death through respiratory illnesses formed a slightly smaller proportion of overall mortality rate. Although respiratory illnesses continued to claim large numbers of the population, the proportionate decline was partly the result of increasing infant and smallpox mortality.[3] These represent two out of three major components in London's mortality profile: infant mortality, epidemic mortality, and endemic mortality including natural ('aged' deaths).[4] In the case of the first and third components, *building pathology* recognises that the most vulnerable people to insanitary, damp and cold buildings are infants, the elderly and those already ill. We have seen that in the modern context this is considered not only from the physiological perspective but also due to the fact that these particular groups tend to occupy buildings for longer hours. It was not, however, within the scope of the early modern medical profession or the

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[1] Harding, 'Housing and Health', p.40.

[2] Ibid.

[3] Ibid., p.38.

[4] Ibid., p.29.

knowledge of the Searchers, upon whose diagnosis the Bills of Mortality were based, to link the death of vulnerable groups to housing conditions other than to use generic terms such as 'infantile' and 'aged'. We can therefore only make deductions when interpreting the research based on the knowledge of the phenomena we are investigating and the science of *building pathology;* this is discussed in more detail below.

As noted in Chapter 1, 'looking for a connection between particular houses or areas of housing and particular health outcomes appears to require a specificity of information that in general is not available.'[5] The value in using *building pathology* to address the main question is that it prompts us to ask further key questions with aim of determining the validity of this research but also of setting limitations on its interpretation. These key questions were set out in Chapter 1 where it was acknowledged that the research has not been able to fully address them all. This is discussed below together with future directions but first it is necessary to reflect on the contribution of the *building pathology* approach and the research used in this thesis.

Mortality in the context of diseases reflects the balance between exposure and resistance. The engagement of *building pathology* has enabled some further enlightenment on neo-classical theories on mortality as determined by exposure and resistance from three viewpoints: social and economic conditions, over time and through exposure potential. We saw in Chapter 2 how Landers expressed these in three formulae, utilising the essential determinants for exposure and resistance, which are conduction, retention and autonomous changes in the virulence of the pathogen for the former, and nutritional status and immunological status for the latter. As well as offering a contextual definition of a building defect and identifying the fundamentals of healthful housing, *building pathology* has enabled deeper exploration of these essential determinants of mortality in considering how these were influenced by failures or short comings in building policies, the function and performance of buildings and user requirements.

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[5] Harding, 'Housing and Health', p. 24.

As noted in Chapter 1, the *building pathology* approach has identified a large number of potential building defects, which may have contributed to the small number of conditions necessary for the spread of enteric and respiratory complaints; this accounts for more chapters being dedicated to the former. The seminal study on *Unhealthy Housing*, edited by Burridge and Ormandy, placed the technical information on shortcomings in housing into a wider epistemological context. We saw in Chapter 2 how two of the contributors to *Unhealthy Housing*, Byrne and Keithley, provided a compelling argument in addressing the problems of correlating building defects with health outcomes. In summary, they have taken a 'realist' rather than a 'positivist' epistemology in their approach to social epidemiology. They have referred to epistemology in this context as the way in which the science of *building pathology* 'knows what is real'.[6] It is concerned with the philosophical justification of our methods of understanding the phenomena we investigate. Thus, through modern research we know the housing conditions necessary for the development of enteric and respiratory complaints and using the *building pathology* approach to interpret the source material has helped identify that some of these conditions existed in early modern London.

Whereas the argument correlating defective housing to health has been set out tentatively, the 'realist' approach does provide greater confidence when interpreting the research material. The collective use of the primary sources has been stressed in this thesis in attempting to answer the questions posed by *building pathology*. It is the Viewers and Surveyors, however, who have been at the forefront for much of this exploration, not least because they were eyewitnesses to building defects. The benefit of complementing the reports of these building inspectors with the other sources was being able to visualize the type of chimneys, roofs, valley gutters, house types they were referring to and the locations in which they were operating. Whereas the Viewers provide valuable information on building defects at the start of the study period, the decline in their office, together with that of the Surveyors in the late seventeenth century, meant that there is a greater reliance on the other sources, particularly statutes that were drafted as a reaction to specific building defects.

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[6] Byrne and Keithley, 'Housing and the Health of the Community' p.56.

Consideration is now given to the questions raised by *building pathology* and the answers provided by the research.

8.1 Revisiting the key questions

The first of these key questions was how far should modern indicators pertaining to structural condition, possession of basic amenities and density of occupation be related to those of an earlier period? Providing an answer to this question is critical to engaging modern *building pathology* and this was justified in Chapter 1 on the premise that the physiology of humans and the performance requirements of building structures, fabric and materials have not changed significantly since the study period. Structural condition pertaining to ill health was the first indicator specified in this particular key question and yet we have seen that it was the historian, Michael Power who in 1970s suggested that perhaps we should give priority to the damp and ruinous condition of a dwelling over the effects of overcrowding. Power anticipated the first key question posed by *building pathology* in considering in the same context the relative influences of structural condition and density of occupation. *Building pathology* has highlighted how dampness referred to by Power can also relate to the third indicator of basic amenities, which is poor ventilation and heating leading to extensive condensation. Power's suggestion for further research in this area was based on his study of crowding in the poorer districts of East London where he concluded that, with the odd exception, overcrowding was not a major issue.[7] We have seen similar findings in a more recent study by Baer in his study of 'the housing of the lesser sort' in other parts of the capital.[8] Harding also highlighted a paradox, identifying the highest levels of occupancy were in the wealthier and yet apparently healthier city centre. Thus, historians have recognised the importance of the modern indicator of 'crowding' in considering the potential for the spread of disease. Historians have also suggested that we investigate more localised factors in the spread of disease in crowded conditions; for example, Champion observed that plague deaths

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[7] Power, 'East London housing', p.244.

[8] Baer, 'Housing for the Lesser Sort', pp.61-88.

within households 'were singular rather than multiple'.[9] With little evidence of widespread overcrowding and some doubt on the virulence of certain pathogens this thesis turned this exploration in the direction suggested by Power.

Structural condition across all social groups has been considered from the aspects of the quality of workmanship and materials used in construction and maintenance of the buildings and the correlation with damp ingress and heat loss. It has been shown in the building pathology analysis that the buildings of all social groups shared similar building practices and materials throughout the study period even though there was a gradual shift from timber-framed buildings to brick in many parts of the city. Thus, the same materials were used but the proportions moved towards brick without any significant improvement in damp proofing and thermal insulation. There were different intentions underpinning building work throughout the study period. The housing market of the early modern capital was based on various landlord and tenant relationships, reflecting economic and social requirements. As noted in Chapter 1, this thesis has some important things to say about the difference between the housing of rich and poor, and the analysis has added further support to the argument that we need to move away from considering that all of the housing of the poor were slums. Although the poor were sometimes housed in temporary structures and converted outbuildings they also occupied buildings formerly constructed for and occupied by wealthier members of society. In the case of the latter, consideration has been given to how the buildings were adapted, used and maintained; the neglect and abuse of a well-built structure could undermine its performance. The poor were not generally tied to onerous repairing covenants and their landlords had little financial incentive to carry out regular repairs as the costs would reduce the relatively low level of the latter's net income. As we have seen, the landlords of the wealthier city centre had a financial incentive to maintain their properties in order to uphold rents.

Attention has been drawn to the economic life of buildings as being 60 years in the modern era, after which significant expenditure is required to carry out repairs,

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[9] Champion, 'Epidemics and the built environment' p. 70.

modernisation and adapt to changing 'user requirements'. In reality, however, such work is carried out in varying degrees throughout the life of a building. The study of property management records in the study period does not provide any consistent understanding on the expectation on the life span of a building but the stipulations contained in the leases are a starting point. The buildings in the city centre were intended to last at least the length of the lease and the tenants were often under a legal obligation to repair and maintain the structure and rebuild in some extreme circumstances. These buildings were also altered, adapted and subdivided, sometimes with a change of tenancy and examples have been given on how such work compromised the performance of the structure and services.

We have seen that many contemporaries, particularly following the rebuilding of the city centre after the Great Fire and the development of the West End estates, questioned the permanency of the buildings due to their poor performance. Some considered the buildings were constructed to last no longer than the length of the lease. Although there would be an awareness on the part of the developer to control construction costs in order to make a return on his investment, the allegation of built-in obsolescence has been difficult to sustain in this study and requires further research. It has been argued in this thesis that what was perceived as built-in obsolescence was in many cases due to deterioration of the structure and fabric following damp ingress and decay as a result of faulty design and construction, and the lack of maintenance. The life span of the most basic of buildings can be enhanced through regular and good quality maintenance. As noted in Chapters 5 and 6, however, maintenance was often carried out on a corrective rather than a preventative basis, for example the privy was already leaking or damp ingress had occurred; as noted, this is still recognised as a major issue in the twenty first century. Thus, as far as the life span of the domestic housing was concerned, this appeared to reflect social and economic factors, a different culture to the sense of permanency in the prestigious owner-occupied mansions, civic and religious buildings.[10]

With regard to basic amenities the building pathology analysis has highlighted, with a small number of exceptions, how poor quality drinking water and

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[10] For a general account of such buildings see Schofield, *The Building of London*.

shortcomings in sanitary arrangements may be related to conditions conducive to enteric diseases. Whereas the research has confirmed the theories and suspicions of historians and the medical profession, the *building pathology* approach has suggested that all social groups in early modern London would have been exposed to these diseases in varying degrees. Modern epidemiological evidence has indicated how different modes of water supply can produce wide-ranging fluctuations in enteric diseases within a relatively small area. The modern studies are relevant in that they have found variations in enteric disease associated with water supplies even where the water has not been the subject to modern filtration and chlorination processes. The epidemiological studies have revealed important data regarding infant mortality, where the infection rate of enteric disease in children of ten years of age and under who live in dwellings with no inside water supply was approximately twice the rate which was observed in children of the same age whose home has an inside water supply and which was provided under pressure. Early modern London's New River was supplying piped water supplies into houses, under pressure, from the early seventeenth century, but as we have seen, it did not become a major source until later into the study period. Modern studies have demonstrated that the further the water source is from the premises, the greater the number of cases of enteric complaints. Applying such data to early modern London is significant because the majority of Londoners still collected water from the public conduits or watercourses including the Thames, or bought it from street sellers who obtained it from the same source. If waterside location was a significant adverse variable for infant mortality rates, as identified by Finlay, this presumably had implications for child and adult health.[11]

Although the provision of indoor flush toilets could not have been met in early modern London, modern studies in underdeveloped countries have shown that the location of privies near or within a dwelling represented a high risk to the conduction and retention of pathogens. Enteric infections in children under ten years of age and rates of morbidity from diarrhoeal disease were found to be particularly high in these studies. Chapters 4 and 6 drew attention to the wealthier city centre of early modern

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[11] Finlay, *Population and Metropolis*, p.103.

London, where the ‘exposure potential’ would have been greatest, because privies were typically located close to or within dwellings.

Thus, with regard to answering this first key question, modern indicators pertaining to structural condition, possession of basic amenities and density of occupation can be related to those of an earlier period. Relating modern indicators pertaining to enteric disease has provided some food for thought in terms of the relative risks of different sources of water supply and the location of privies. The research has been particularly revealing with regards to the many sources of damp ingress and heat loss.

The second key question raised by *building pathology*, was how significant was the ‘form’ of the dwelling, for example whether it was a single house, multi-occupied, or a combined ‘live-work’ type. This is not set in the context of density of occupation as this was addressed in the previous question but relates to how the building was used in terms of the layout of the accommodation and activities undertaken by the occupants. This pertains to ‘user requirements’, one of the four defects recognised in *building pathology* that could have an impact on health. ‘User requirements’ is a theme that flows throughout the building pathology analysis for we have seen how they influenced the function and performance of the buildings and their services and also undermined building policies. ‘Fitness for purpose’ has been identified as an important measure of how a building matches or conflicts with the requirements of its user. We have seen how user requirement studies attempt to identify fitness for purpose in terms of activities, that is the things people do, and human needs, such as physical, psychological, physiological and social. For a building to be fit for its purpose it must allow the occupants to carry out their activities economically and conveniently, and significantly for the purposes of this thesis, have a satisfactory environment. Whereas it has been possible to study floor plans in considering how daylight and ventilation may have been compromised by the arrangement of partitions and windows, the research has not been able to answer this key question fully. There are gaps in our knowledge in terms of activities, or more specifically the patterns of occupancy and behaviour of the users. Attempts to fill some of these gaps have been sought through reference to the social topography.

We have seen how early modern London was driven by a commercial enterprise and the users of the buildings aimed to be located near their markets. We

have noted that Power identified groups of occupations in the city centre prior to the Great Fire, and these included: groups selling commodities or services; craft groups, making and perhaps selling commodities; semi-skilled groups.[12] Only the semi-skilled customarily worked away from their homes and therefore a large number of the buildings were occupied on a 'live-work' basis. This is significant in attempting to address the second key question, in that there was a greater potential for the occupants of these buildings to be exposed to building-related illnesses. This pattern of occupancy appears to have continued into the post-Fire period where, other than a slight fall in population density, the social topography of the city centre did not seem to change greatly.[13] Thus, the live-work dwelling form has been the dominant dwelling type studied and it has been shown that the commercial processes in these buildings were not generally of a type that would represent a health risk. The city centre prohibited obnoxious trades and according to Power, hazardous industrial processes were rarely taking place in live-work buildings in the poorer East End and wealthier West End.[14]

It has been observed that, with the rare exception, multi-occupied buildings were more closely associated with buildings belonging to the wealthy, with households larger than in the poorer districts; wealthy households would include servants and apprentices. Whether the hazards of 'crowding' within this part of London could be diluted amongst the various floor levels is conjecture as there is a lack of information on such behavioral patterns. A single house, devoid of commercial activity, in the wealthier parts of London would have a similar type of household. A smaller household generally occupied a single modest dwelling in the East End and Baer found similar patterns of occupation in sheds and converted outbuildings in other parts of London.[15] Theses dwelling types were generally occupied by a social class working away from the building, or at least in the case of

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[12] Power, 'The social topography' p.210.

[13] Harding, *et al People in Place*, p.34.

[14] Power, 'East and West', pp.174-177.

[15] Baer, 'Housing for the Lesser sort in Stuart London' pp. 70-2.

the head of the household. Again, there is a lack of information on whether the rest of the household occupied these particular dwellings for significant periods of the day.

In the modern era patterns of occupancy are considered key in the study of relationships between housing and health. Susan Smith produced a recent review of the major studies. Most attention has been paid to respiratory disease, which she recognises as being traditionally linked with poor housing conditions.[16] Significantly, the review of these studies draws attention to particular age groups and gender rather than social class as being particularly vulnerable. It has been argued that young children, their mothers and elderly people are the groups to be most affected, simply because they spend more time in the home than others. A number of the studies have found links between damp housing, the presence of mould and high rates of asthma and respiratory illness, especially among children. In the case of elderly people, it has been argued that damp, cold houses are an important factor in excess winter deaths in Britain and not just in the extreme form of hypothermia, but also in increased susceptibility to coronary and cerebral thrombosis and respiratory disease.[17] Consideration must therefore be given to the possibility that these complaints may have contributed significantly to the generic term 'aged' deaths recorded in the Bills of mortality.

As noted in Chapter 1, Harding has drawn attention to the problem in assuming that most individuals lived long enough in one property for its effect on health to be significant.[18] Smith's review has also focused on similar problems facing researchers in the modern era. Significantly, respiratory illnesses are linked with current or short-term exposure to defective housing. Long-term implications for heath may be experienced many years later, however, perhaps at a time when current housing conditions are good. Thus, in the early modern context consideration need to be given to the possibility that people dying later in life from a respiratory illness may have been affected through past exposure to a damp and cold house. Perhaps some of

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[16] Professor Susan Smith, 'Housing and Health: A Review and Research Agenda,' cited in Byrne and Keithley, 'Housing and the Health', p.43.

[17] Ibid.

[18] Harding, 'Housing and Health', p.24.

the post-Fire deaths through respiratory illness in the city centre related to pre-Fire exposure to defective buildings.

The third key question concerned how far the location and the environment of housing rather than the condition of the individual dwelling has to be taken into account. As noted in Chapter 2, although it may be perfectly possible to relate housing conditions to the health of an individual resident in a particular dwelling in the twenty first century, such information is not available for the early modern period. Research has even highlighted inherent problems with case-centered studies in the modern period, however, because of the lack of certainty over accurate diagnosis in the cause of illness in the individual patient. On this basis, together with the passage of time, it would not be possible to rely upon the accuracy of diagnosis of early modern medical practitioners. Byrne and Keithley argue, however, that it is more important to conceptualise the impact of differential housing conditions on the aggregate health of whole communities; this is the basis of 'social epidemiology' and this modern approach has been engaged in Chapter 7. It is the discourses in *building pathology* that have justified the approach of viewing the health of early modern London from the perspective of the community and vindicating the inductive reasoning in the work of John Graunt. We have also seen how the historian Justin Champion has, in all but name, used a similar approach in his study of the plague. It has been stressed that the selection of the aggregate technique has not been made through default, brought about by the short-comings in clinical studies. Rather the aggregate technique through the study of community health recognises the causal systems of diseases, comprising proximate determinants. In the context of early modern London, we have seen that these proximate determinants may have varied in their influence through social and economic circumstances, over time and exposure.

The socio-economic analysis in Chapter 7 suggests that the wealthy had greater resources to maintain and improve their properties, and access to a larger number of fireplaces for warmth. The study of water distribution in the city also provided an opportunity to map social topography and identify the location of different sources and quality of supplies. All things being equal, the streets and certain lanes within the city centre, together with large brick-built West End developments would appear to have been relatively healthy environments. The building pathology analysis has, however, identified the potential for the conduction and retention of

pathogens, as well as damp ingress and heat loss in the buildings of all social groups; this satisfies two out of the three key determinants influencing mortality in the context of social and economic conditions. The third determinant is nutritional status. Harding observed that 'Andrew Appleby found very limited correlation between the nutritional status of London's populace (inferred from the varying price of bread) and the chronological incidence of disease, but this does not mean the health of the poor was not adversely affected by the physical conditions in which they lived.'[19] This thesis has argued that the nutritional status of all social groups would have been under attack due to the relatively poor performance of the buildings particularly in the interaction with the external environment. The climate of the study period imposed extreme demands on vulnerable buildings and their services. Although there were variations in the quality of buildings occupied by different sectors of the population, the demands of the climate were largely exogenous to economy and society.

The building pathology analysis has concluded that despite the intervention by regulatory authorities into the built environment, the 'improvements' did not address conditions pertaining to the spread of enteric and respiratory complaints. This offers one explanation to the conundrum highlighted in Chapter 1, where infant mortality increased in the wealthier city centre after the Great Fire despite the renewal of the urban fabric.[20] This does not, however, answer why deaths caused by enteric diseases were decreasing towards the end of the study period. Analysing the formula expressing mortality over time has offered an explanation. We have seen how conduction and nutrition were also key determinants in this context; the other two were immunological status and pathogen load. Consideration is given to the possibility of the population building-up some form of immunity but this is rarely discussed in the context of enteric diseases. More importantly, however, immunological status is chiefly a function of prior exposure; the response of the immune system can be impaired by inadequate nutrition.[21] In having already argued that those housing conditions identified in this thesis would have reduced nutritional

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[19] Harding 'Housing and Health', p. 40.

[20] Harding *et al*, *People in Place*, p.29.

[21] Landers, *Death and the Metropolis*, p.36.

status, it is unlikely that immunological status would have had a significant part to play in the decline in enteric disease.

As noted in the last Chapter, Landers suggests that we should look to the 'pathogen load', the fourth determinant of expressing mortality over time. He offers two possibilities. First, the higher temperatures of mid-summer towards the end of the sixteenth century may have impeded the spread of the pathogens. The second possibility need not exclude the first, but is more to do with a change in the nature of the pathogen. It is possible that the strain of the disease was more infective but less severe later in the eighteenth century.[22] These factors were therefore also exogenous to economy and society and it is for this reason that this thesis has questioned whether the study of economic or social groups in the context of enteric and respiratory diseases helps or hinders epidemiology. Thus, the building pathology analysis has been largely focused on exposure potential across all social groups. Although it is accepted that the research has not answered fully all the questions raised by *building pathology*, it is argued that the building defects identified in this thesis would have caused a higher rate of enteric and respiratory diseases.

8.2 Future Directions

It has been acknowledged in this explorative study that a full explication of this topic is beyond the scope of a single PhD thesis. The following is a brief summary of potential topics for future studies. Further research should explore how much time people spent away from their urban, domestic environment, and the influence of time spent in rural locations, particularly in childhood for urban migrants, or at weekends and summer months for the wealthy. Thought should also be given to the way in which contemporaries were able to mitigate building defects through the use of space or the impact of household furnishings. The influence of occupations or early years environments on health have only been touched upon within the limitations of this thesis. It has been recognised in the opening Chapter that other diseases may be associated with the built environment and the holistic early modern concept of health, which would have included the emotions and mental health will also require attention.

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[22] Ibid.

Mental illness and general stress-induced morbidity has been the subject of recent research by medical researchers [23] and historians.[24]

As noted in the opening Chapter, the *building pathology* approach invites comparison. Answering the question in Chapter 1 'why London?' and 'how can it be studied?' in Chapters 2 and 3 may help in the preparation for future comparative work. The systematic approach followed in the building pathology analysis of considering failures in building policies, the function and performance of buildings as well as the user requirements provides a template for the study of other early modern towns. It is recognised, however, that there may be a different emphasis on the sources used. Cockayne admits in her comparative study of 'filth, noise and stench' in London, Oxford, Bath and Manchester that these towns were selected because 'there are sufficient sources to conduct in-depth studies, and they allow for comparisons between different urban centres.'[25] The Viewers and Surveyors have been an important source in the study of London but there may be a lack of similar structured organizations in most other British towns. The equivalent building inspector organizations in other towns may well have been set-up on an *ad hoc* basis. There is, however, evidence of Viewers operating in Oxford and Chapter 4 has drawn attention to a similar system of building inspectors in contemporary Paris. The opening Chapter highlighted how Paris shared many other aspects with London such as 'a history of centuries of development and redevelopment on the same spot, resulting in a congested urban plan that was invested with meanings derived from traditional uses and ownerships but modified by newer practices.'[26] Chapter 4 argued that Paris exercised an overt 'creative' form of town planning, in recognition that congestion within a thriving metropolis was inevitable and the French drafted their regulations on building standards accordingly. London's reaction was more covert, prohibiting some

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[23] Smith, 'Housing and Health' cited in Byrne and Keithley, 'Housing and the Health', p.43.

[24] Mental Illness is a subject covered extensively by Roy Porter in *The Cambridge History of Medicine*, pp238-259; *The Greatest Benefit*, pp. 493-524; 'Madness and its institutions', in Andrew Wear (ed.), *Medicine in Society.* Daniel Antoine of the Archaeology department of UCL; (personal meeting 11 December 2007 at University College, London).

[25] Cockayne, *Hubbub*, p.9.

[26] Harding, *The Dead and Living*, p.3.

development, while ignoring or permitting others, subject to some modification. Our attention has been drawn to 'environmental engineering' in France, whereas confusion reigned in London.

The original mediaeval urban centre of Edinburgh provides a rare British example of the type of city more typically associated with continental Europe, with limited land confined within the ancient walls and the natural topography. According to Howard, the old town was developed through a form of town planning. The single main thoroughfare widened in the centre to make space for a market. This 'Royal Mile' served as the setting for ceremonial and mercantile activity, rather than as a line of communication.[27] From 1550-1660 Edinburgh grew dramatically and became Scotland's largest city, both in terms of population and volume of trade; the population was estimated at about 30,000 in the seventeenth century.[28] The confined space encouraged the construction of multi-storey buildings reaching much greater heights than most English counterparts. The 'vertical social topography' of Edinburgh provides a contrast; whereas London's city centre had numerous social groups living almost cheek by jowl in the respective streets, lanes and alleys, different social groups often occupied the same building in the Scottish capital, with the wealthier on the lower storey.

Norwich represents a good example of an English city, surrounded by ancient walls. Corfield has described how there was more space within the walls than London and has suggested that it may have been laid out for future expansion. Despite what may be interpreted as a form of town planning, the growth, as described in Chapter 1, tended to worsen the living conditions in the city centre, and increase levels of mortality during the non-plague years. Corfield has referred to Bills of Mortality from 1582 to 1646 as well as Hearth Taxes in analysing the social topography and observed that there was a lack of evidence to suggest 'that there was any radical reduction of mortality through improvements in standards of public health and living

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[27] Deborah Howard, *The Architectural History of Scotland: Scottish Architecture from the Reformation to the Restoration, 1560-1660* (Edinburgh University Press, 1995), p. 109.

[28] Ibid., p. 116.

conditions.'[29] In terms of considering failures in building policies, Corfield refers to the legislators being 'sanguine about the specifically urban problems produced by growth, such as the increased problems of sanitation and housing, supplies of food and water.'[30] Galley's study of York, another city surrounded by walls, has been of great value already in this thesis, not least in comparing its physical remains. The recent completion of the Hungate excavations in the city may be a significant source for a *building pathology* study. John Speed's map, circa 1610 shows the street of Hungate running down to the River Foss, where it is noted to be wider than it is today. A late seventeenth-century map shows the Hall of the Cordwainers, along with housing belonging to wealthy merchants. An environmental issue is also referred to in the form of a 'midden.'[31] It could be argued, however, that no comparative study of urban centres in early modern Europe would be complete without involving the greatly urbanised Holland. Thus, the template offered by the building pathology approach will enable comparative studies to be made and perhaps provide answers to the some of the outstanding questions raised in this thesis.

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[29] Penelope Corfield, ' A provincial capital in the late seventeenth century: the case of Norwich' in Clark and Slack (eds.), *Crisis and Order*, pp. 265-9.

[30] Ibid., p.269.

[31] http://www.dighungate.com

Appendix A: Building Audits

Building pathology has recognised that in the past the property industry's assessment of buildings has typically lacked accurate and comparable information. The practice of *building pathology* demands a broad and detailed assessment of buildings and this has resulted in the production of building audits.[1] These are checklists and have been adopted in this thesis to collect and present information, and to make comparisons between the buildings studied in the building pathology analysis. The audits summarise how the buildings were constructed, serviced and used.

Audit A for a conglomerate form of house: 3-4 St. Pancras Lane

General Details [2]

- These two properties lay on the south side of St. Pancras Lane, in the parishes of St. Pancras and St. Antonin.
- Uses: Various.
- Form of construction: Conglomerate (brick, stone and timber).
- Number of storeys: Two plus garrets and cellars.
- Site and external environment: narrow lane, opposite the church of St. Pancras. Gardens to the south; two open yards to the centre.

Materials Audit

- Foundations: Assume supports to stone wall were built according to custom; the structure had stood since the fourteenth century (see below). Brick foundations to brick walls; assume brick plinth supporting base of timber frame. Little evidence of pile foundations in this part of the city.
- External walls: The substantial stone wall which ran along about 2/3 of the length of the western side of the property at that time was probably identical with the wall recorded in that position in the early 14th century, and the 17th-

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[1] Watt, *Building Pathology*, pp.82-3.

[2] The sources are Keene and Harding, *Cheapside gazetteer* (HG, 1; *Cheapside*, site 145/ 14-15); *The London Surveys of Treswell*, pp. 106-7.

century structural arrangements probably reflected those of the medieval house. Brick walls to south-west; timber frame to the rest of the building.

- Roof Structure and covering: Assume to be oak frame, covered in tiles to main area; flat lead roof above garret on the east side measuring 13’9” x 3’.
- Internal walls and partitions: Timber frame, some of wainscot. Timber pillars supporting the structure in the middle room towards the north of the plan. Brick partitions to south east corner.
- Floors: Cellar was solid construction; upper floors of suspended timbers.
- Windows and Doors: two prominent four-light stone windows to the hall and parlour, and a third in in the slighter east wall on the hall, probably of timber. Wainscot to some doors.
- Ceilings: some of wainscot.

Services Audit

- Water supply: A pump and cistern of lead weighing 4.5 cwt is recorded in 1597; a number of changes and improvements had been made to the house by 1611 and a supply of water from the New River had replaced the pump.
- Heating: Chimneys but details are only provided for one of the two tenancies where four chimneys are specified.
- Lighting: windows; assume artificial lighting to internal rooms.
- Ventilation: windows and chimneys.
- Drainage: Details only provided for one of the two tenancies: one privy shown on the ground plan, mid-way down the east side of the plan; house of office contained in a chamber above the kitchen possibly connected to the cess-pit by a chute.

Performance

- Heat Loss (heat transference or U-Value): External stone wall is 2.5, brick walls 2.0 and timber 2.86W/m2 K.
- Glazing: 11.1 m2 represents 8.6 % of frontage.
- Use: Mixed commercial and residential use.

Additional Comments

- The Great Fire destroyed the two buildings.

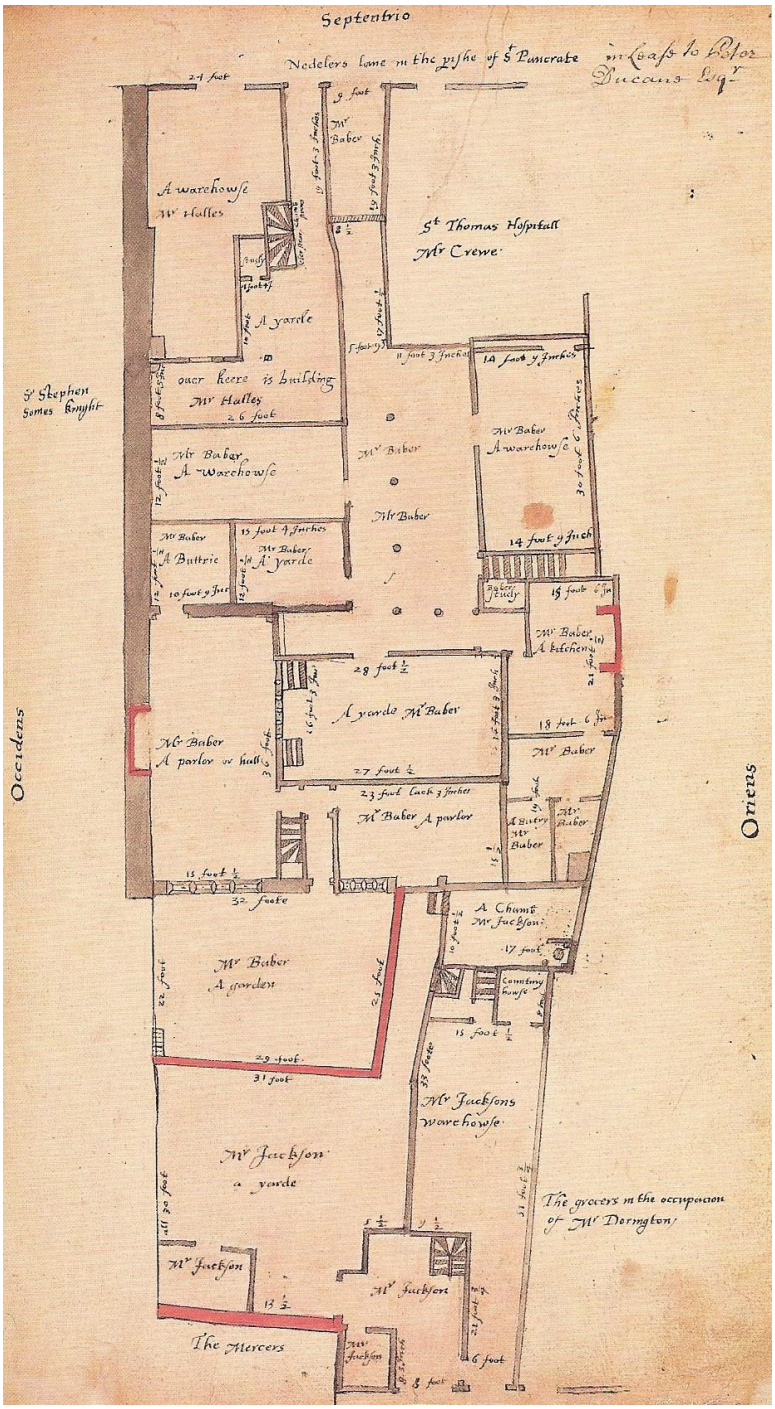

Figure A.01. The ground floor plan of 3-4 St. Pancras Lane.

Audit B for timber framed house: 16 Cornhill

General Details[3]

- A property on the south side of Cornhill opposite the Royal Exchange, backing onto part of 'the stone house in Lumberd Street.' The property was surveyed in 1612 by Treswell and belonged to the Clothworkers' Company.
- Uses: Commercial at ground and basement level; kitchen to rear but the rest of the residential use is to the upper floors.
- Form of construction: Timber frame.
- Number of storeys: Three storeys plus a garret.
- Site and external environment: Confined site, with very little out door space; small yard to centre (see plan).

Materials Audit

- Foundations: beneath walls to cellars under shop and warehouse; brick plinth to rear supporting oak base plate.
- External walls: Oak frame; wattle and daub.
- Roof Structure and covering: Oak frame, covered in tiles; flat lead roof above gallery.
- Internal walls and partitions: Timber frame.
- Floors: suspended timbers, including those above cellars.
- Windows and Doors: Wood.

Services Audit

- Water supply: Well in yard, shared with the neighbouring property; in an earlier century the well may have been dug in the courtyard of a larger house, which was sub-divided in this way to make space for smaller houses.[4]
- Heating: Chimney to hall and adjoining chamber; kitchen and chamber above; to the chamber next to the street and adjoining chamber at second floor level.

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[3] Sources are *The London Surveys of Treswell*, p.65 and Clout, *The Times History of London,* p.63.

[4] Clout, *The Times History of London,* p.63.

- Lighting: Natural; dark internally as the front is north facing; the rear windows are blocked by the adjoining stone house.
- Ventilation: Windows and Chimneys. No through ventilation from front to back as it adjoins the 'stone house'.
- Drainage: No reference is made to privy. With very limited space in the yard it is possible that there were indoor privies on the upper floors.

Performance

- Heat Loss (heat transference or U-Value): External wall construction: 2.19 W/m2 K
- Glazing: 11.1 m2 represents 8.6 % of frontage.
- Use: A compact domestic unit; at the ground floor street front there was a shop, with a warehouse behind. Living quarters were on the first floor and above. A fine hall graced the front of the house, while a gallery led to further rooms over the rear kitchen. Merchandise was stored in the large cellars with an entrance to the street.[5]

Additional Comments

- The gallery shown above led to a recent extension at first floor level and as referred to as 'the new building'.

[5] Ibid.

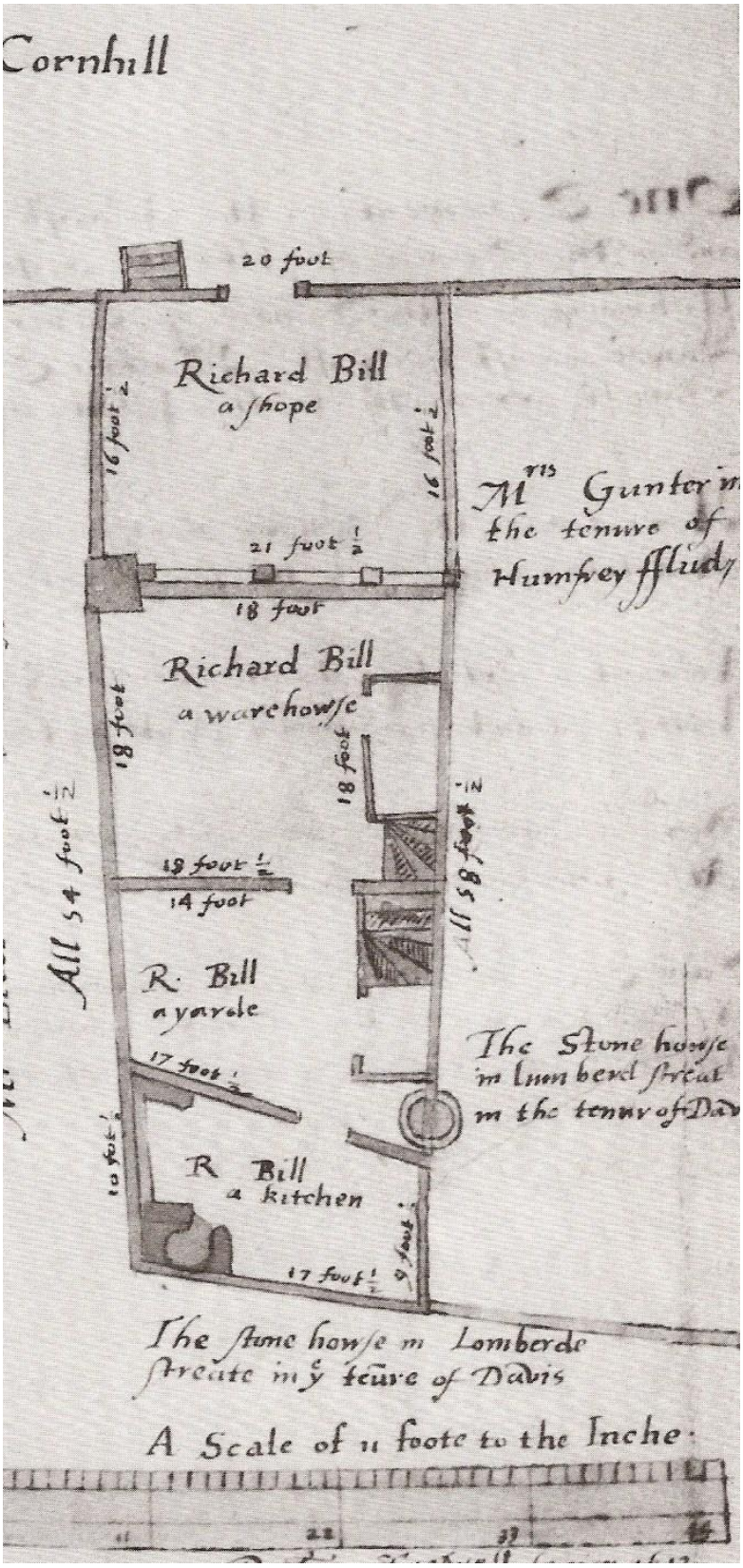

Figure A.02 Ground Floor Plan. North is to the top of the plan.

Audit C for a shed

General Details

- This is a generic structure (see figure 3.06).[6]
- Uses: residential.
- Form of construction: Timber frame.
- Number of storeys: maximum of two.
- Site and external environment: Various but usually built against a more substantial dwelling or churches. No designated outside space.

Materials Audit

- Foundations: no evidence of foundations
- External walls: wood weatherboard cladding.
- Roof Structure and covering: boards, no records of tile or lead
- Internal walls and partitions: Timber frame
- Floors: oversite soil or mud, possible covered in straw
- Windows and Doors: Wood. Some evidence of glazing to windows on figure 3.01, although see comments on accuracy of record drawing in chapter 3, section 3.2.

Services Audit

- Water supply: Remote supply
- Heating: Some sheds have been recorded with chimneys for wood burning.
- Lighting: Poor
- Ventilation: Windows and Chimneys.
- Drainage: Remote, off-site.

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[6] Sources are Power, 'East London housing' p.345; Baer, Housing of the Lesser Sort' p.81; City Viewers and Surveyors Certificates (see chapters 4-6).

Performance

- Heat Loss (heat transference or U-Value): External wall construction: 3.86 W/m2 K
- Glazing: No information
- Use: Purely residential, typically one household.

Audit D for a brick house: 3 Amen Court, London EC

General Details [7]

- 3 Amen Court is one of three Canon's houses, built by Edward Woodroffe between 1671 and 1673 (See figure 3.12).
- Uses: Canons Residentiary of St. Paul's Cathedral.
- Form of construction: Load bearing brick.
- Number of storeys: Three, plus garret and cellar.
- Site and external environment: Narrow lane; garden at the rear.

Materials Audit

- Foundations: Brick footings below basement level.
- External walls: 450mm-225mm (18"-9") solid brick.
- Roof Structure and covering: softwood and tiles.
- Internal walls and partitions: Brick and timber.
- Floors: solid to basement; suspended timbers to upper floors.
- Ceilings: plaster
- Windows and Doors: originally wood casements, later changed to sashes.

Services Audit

- Water supply: pump
- Heating: chimneys
- Lighting: windows
- Ventilation: windows and chimneys
- Drainage: Privies and cess-pits location not confirmed.

Performance

- Heat Loss (heat transference or U-Value): External wall construction: 2.10 W/m2 K.

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[7] Sources are The Wren Society, Volume 13, pp.51-63, St Paul's Cathedral Library and Archives, a survey undertaken by the writer in his capacity as a Chartered Building Surveyor on 8 September 2008.

- Glazing: 11.1 m2 represents 8.6 % of frontage.
- Use: Residence for Canons.

Additional Comments

Survey undertaken in 2009 revealed that:

- Roof timbers have been replaced.
- Parapets rebuilt with damp- proof courses.
- Repairs to external walls.
- No evidence that a damp-proof course inserted to base of walls.

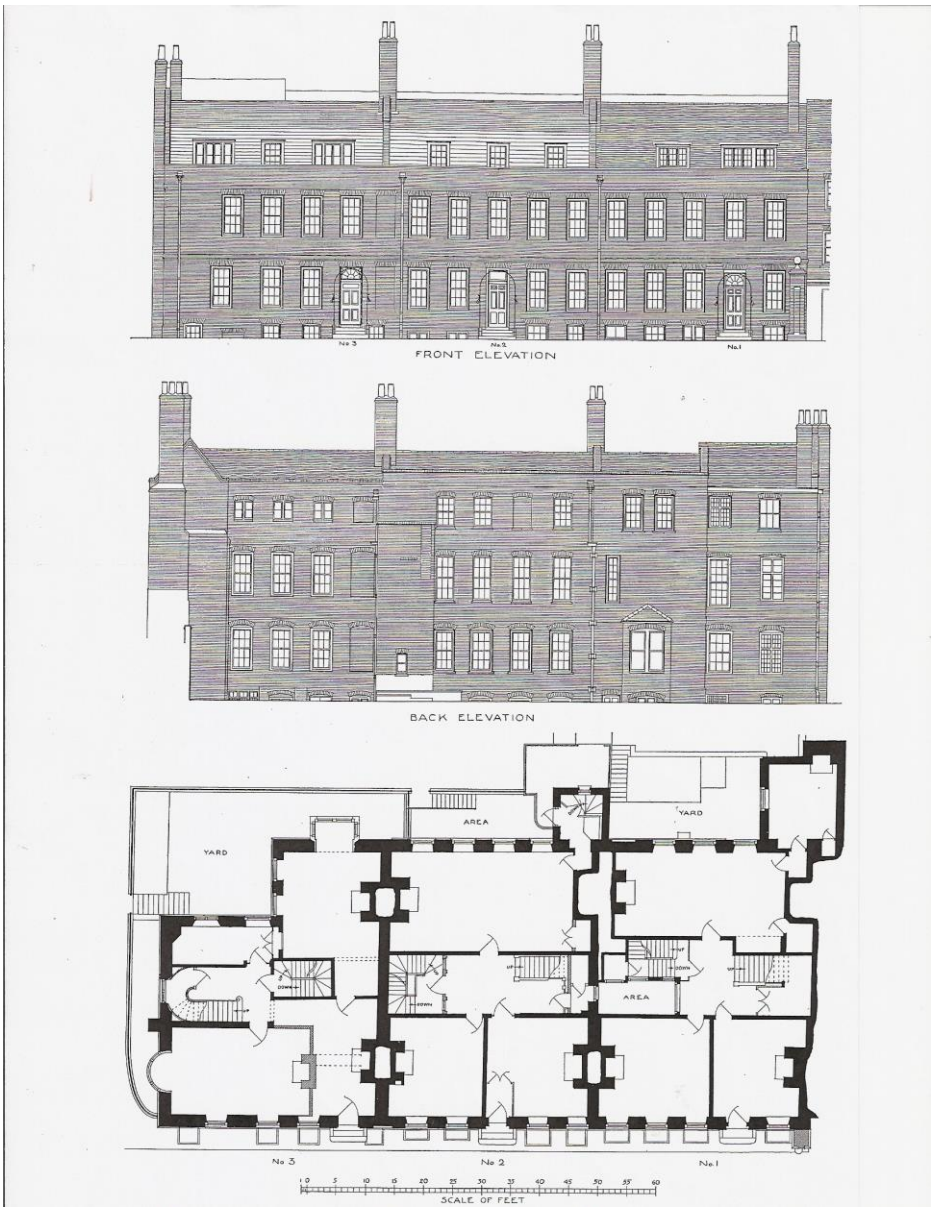

Figure A.03. The front and rear elevation and ground floor plans of 1-3 Amen Court.

Appendix B: The Building Pathology Database

As part of the systematic approach a database has been designed and constructed around the *building pathology* definition of building defects.[1] The purpose of the database is not just to store research material, but also to provide an analytical tool to assess whether the *building pathology* definition of defective housing can assist us in defining and determining the defects in London's early modern housing. There are three main sources for the database, the City's Viewers and Surveyors and the records of property management in the *Historical Gazetteer* of Cheapside.[2] The database was designed with two tables, the first covering the buildings and the second comprising reports of problems or defects in specific buildings (figure B.01). The 'Building Table' lists the buildings I have researched. The following information is entered for each building: name/identity of a specific property; its location (parish); street (if known); construction type (timber, stone, brick or a mixture, that is, a conglomeration). As well as providing a detailed account of a particular house, there is a link to the 'Report Table.'

The 'Report Table' is also organised by individual buildings, but focuses on the reports of building defects. In some cases there may be more than one report on the same property identifying different symptoms due to a specific defect, such as those relating to damp, decay, structure and sanitation. These four symptoms have been identified as having an effect on the health of the occupants. Each report gives the following: name/identity of a property corresponding to the Building Table; symptom (as given above); the cause of the defect, that is, failure of function, performance, statutory and user requirements; a description of the 'requirement failure' and symptom is given in the fourth column from the left. The source is given in the next column, including the date of the original report; as some reports were updated, the date the report was entered on the database is given in the next column; a generic 'historic date' of 'Pre and Post' fire is given in the last column. At the top

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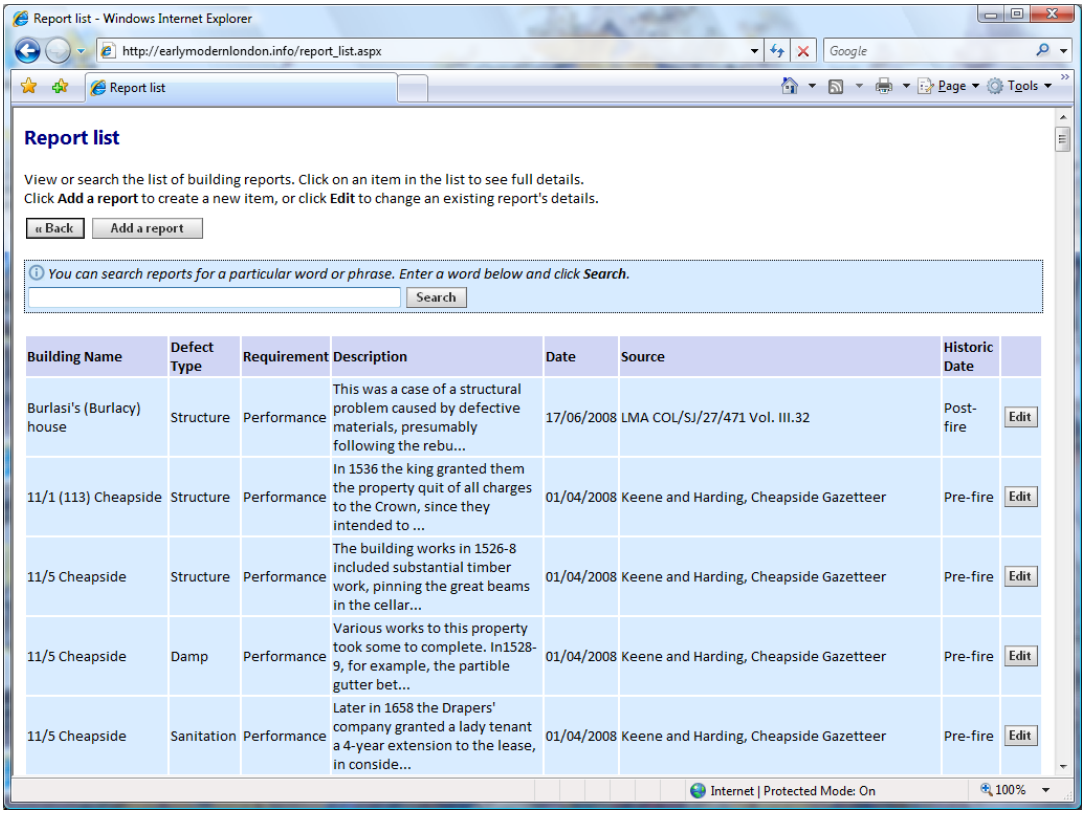
[1] My design of the database was constructed by Peter Cornish, Gatehill Software, Pinner, Middlesex, http://www.gatehillsoftware.com

[2] Derek Keene and Vanessa Harding, *Historical gazetteer of London before the Great Fire* (Centre of Metropolitan History, 1987).

of both the ‘Building’ and ‘Report’ Tables are ‘search’ buttons, which have enabled me to search for specific names or phrases and call-up minute detail, and lists. This has proved very useful when compiling data, statistics, pie-charts and references for this thesis.



Building Name	Defect Type	Requirement	Description	Date	Source	Historic Date	
Burlasi's (Burlacy) house	Structure	Performance	This was a case of a structural problem caused by defective materials, presumably following the rebu...	17/06/2008	LMA COL/SJ/27/471 Vol. III.32	Post-fire	Edit
11/1 (113) Cheapside	Structure	Performance	In 1536 the king granted them the property quit of all charges to the Crown, since they intended to ...	01/04/2008	Keene and Harding, Cheapside Gazetteer	Pre-fire	Edit
11/5 Cheapside	Structure	Performance	The building works in 1526-8 included substantial timber work, pinning the great beams in the cellar...	01/04/2008	Keene and Harding, Cheapside Gazetteer	Pre-fire	Edit
11/5 Cheapside	Damp	Performance	Various works to this property took some to complete. In1528-9, for example, the partible gutter bet...	01/04/2008	Keene and Harding, Cheapside Gazetteer	Pre-fire	Edit
11/5 Cheapside	Sanitation	Performance	Later in 1658 the Drapers' company granted a lady tenant a 4-year extension to the lease, in conside...	01/04/2008	Keene and Harding, Cheapside Gazetteer	Pre-fire	Edit

Fig. B.01. An extract from the ‘Report Table’ on the *building pathology* database, where information on defective individual buildings is stored.

The City’s Surveyors were appointed after the Great Fire of London and it therefore follows that the Viewers’ reports and property management records make-up the contents of both the ‘Building’ and ‘Report’ tables in the pre-Fire period, recording timber-frame and conglomerate forms of construction; the latter are described on the database as a mixture of timber and brick but some sections of stone walls are occasionally mentioned. As noted in Chapter 4, the City’s Surveyors took the dominate role in the rebuilding of the city centre and information contained in their certificates make-up the whole of post-Fire entries in the ‘Building Table’ and the majority of those in the ‘Report Table’. Although chapters 4-6 have noted the diminishing role of the Viewers in the post-Fire period, they were still involved in resolving disputes outside the provisions of the Rebuilding Act of 1667 and occasionally accompanied the Surveyors on views. As the aim of the *Cheapside*

Gazetteer was to document the histories of properties up to the Great Fire no records of post-Fire building defects have been entered onto the database from this source but there are ten interesting cases of problems pertaining to reconstruction. With regard to both the 'Building' and 'Reports' tables my sources have been assessed against this analytical framework. This has enabled me to produce a critique of these sources, in terms of their value and what they can add to the bigger picture. The Building Pathology Database is accessible at the following website:

http://earlymodernlondon.info
Username: bpluser
Password: London2015

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London Metropolitan Archives, 40 Northampton Road, London EC1R 0HB

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The year of excavation is shown by the last two digits of Museum of London sitecode.

BDE00 Bow Bells House, Bread Street EC4

BII00 5 Billiter Street EC3

FHC00 56-59 Fenchurch Street, 18 London Street & 76 Mark Lane EC3

GHT00 Blossom's Inn, 20 - 30 Gresham Street, 20 – 23 Lawrence Lane, 3 – 6 Trump Street, 1- 10 Milk Street & Mumford Court EC1

KWM00 68 King William Street EC3

KHS98 Kent House, 11-16 Telegraph Street & Copthall Close EC3

LOD00 10-15 Lombard Street EC3

MGA00 19-31 Moorgate EC2

MTN00 Middle Temple Hall kitchens, Middle Temple Lane EC4

NGT00 Paternoster Square, Area 4 and Paternoster Row EC4

POY00 Mercers Hall, Ironmonger Lane EC2

QUS00 29-30 Queen Street, 1-7 Great St Thomas Apostle EC4

QVR00 Walker House, 87 – 95 Queen Victoria Street EC4

SLY00 Juxon House, St. Paul's Churchyard EC4

SOL99 Athene Place, 66-73 Shoe Lane and 22 St Andrew Street EC4

SUN86 Sunlight Wharf, Upper Thames Street

TGT00 2-2a Throgmorton Avenue EC2

TL74 Trig Lane, Upper Thames Street, EC4

VHY89 Vintners'' Place, Upper Thames Street, EC

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