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Using mixed methods to investigate factors influencing reporting of livestock diseases: A case study among smallholders in Bolivia[☆]



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ABSTRACT

Livestock disease surveillance is particularly challenging in resource-scarce settings, where disease events are often unreported. Surveillance performance is determined as much by the quantifiable biological attributes of the disease, as it is by motivations and barriers perceived by livestock keepers for disease reporting. Mixed methods designs, which integrate the collection, analysis and interpretation of qualitative and quantitative data in a single study, are increasingly used across different disciplines. These designs allow for a deeper exploration of the topic under investigation, than can be achieved by either approach alone.

In this study a mixed methods design was used in order to gain a greater understanding of the factors that influence reporting of livestock diseases in Bolivia. There is a need to strengthen passive surveillance in this country, among other reasons as part of an eradication programme for Foot and Mouth Disease (FMD). Findings revealed livestock keepers in the study area were extremely unlikely to report the occurrence of livestock health events to the Official Veterinary Services (OVS). Communication outside the local community occurs more often through alternative routes and this is positively correlated with disease awareness. The main barriers to disease reporting identified were a lack of institutional credibility and the conflicting priorities of the OVS and livestock keepers.

As for other animal and human diseases across the developing world, passive surveillance of livestock diseases in Bolivia should be enhanced; this is urgent in view of the current FMD eradication programme. Increasing timeliness and smallholders' participation requires a detailed understanding of their likely actions and perceived barriers towards disease reporting. These insights are most likely to be developed through a holistic mixed methods approach of quantitative and qualitative analyses.

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1. Introduction

Early and accurate detection of disease events is vital in order to respond to emerging and re-emerging diseases before they develop into large scale epidemics and also to monitor disease control (Paskin, 1999; Halliday et al., 2012). In resource-scarce settings, with an important presence of smallholders, financial constraints and logistical

difficulties make the establishment of surveillance systems for livestock diseases challenging. Furthermore, animals kept by smallholders play diverse roles in people's livelihoods that go beyond the trade of livestock products (Upton, 2004; Randolph et al., 2007). Surveillance and control programmes designed for commercially oriented producers may lack relevance to smallholders' needs and as a result there may be low motivation for compliance among this group (Mariner, 2009; Halliday et al., 2012).

Quantitative epidemiological research is well suited to capture the biological and measurable aspects of surveillance systems' performance (Thurmond, 2003; Stark et al., 2006). However, an understanding of the motivations and barriers for disease reporting is better approached from a research paradigm where the emphasis is on interpretation and subjective meanings of data gathered by qualitative methods (Lemon et al., 2007), reflecting the potential of combining measurable estimates from quantitative research with people's interpretations and meanings. Approaches to research that involve collecting and analysing quantitative and qualitative data in a single study have been successfully undertaken in recent years to investigate a broad range of issues in disciplines such as education, social policy and health services (Woolley, 2009; Creswell and Plano Clark, 2011).

Mixed methods research represents an integrative investigation of quantitative and qualitative data gathering, analysis and interpretation. The rationale behind its use is that the combination of the two methods can provide a better understanding of the research problem than either approach alone, with each method complementing each other yet keeping its own philosophical foundations (Creswell and Plano Clark, 2011). There are different mixed methods designs where quantitative and qualitative data can be collected, analysed and integrated at different stages and in different sequences. The choice of a certain design depends upon the research question to be addressed, previous knowledge and timing. For example, a study can implement the quantitative and qualitative strands during the same phase of the research process and then combine the results in an overall interpretation. Alternatively, a design can be implemented in two phases using sequential timing, with one strand (qualitative or quantitative) following the other. When the collection and analysis of quantitative data takes place first, the subsequent collection and analysis of qualitative information, is designed so that it follows on from the results of the preceding quantitative phase. The qualitative results are therefore used to explain and understand the initial quantitative results; as such this design is often called *explanatory* sequential design. Similarly, a design may begin by collecting and analysing qualitative information, and build a second quantitative phase to test or generalise the initial findings. This is known as *exploratory* sequential design (Creswell and Plano Clark, 2011). In this design the qualitative part gives the bases to either ensure the quantitative instruments are relevant and adequate or to identify emerging questions to be tested and quantified (Stoller et al., 2010; Wesely, 2012).

Surprisingly, mixed methods designs have not been widely used in the context of animal health and disease reporting. Our study is designed as an initial effort to

address this gap, and provide a fuller picture of the factors that influence reporting of livestock diseases in Bolivia.

Existing studies have predominantly taken a quantitative approach, often using the term 'qualitative data' when implying classification of categorical variables with words. Therefore the use of the term qualitative in the context of quantitative epidemiological studies may lead to confusion. In this study we use the term "qualitative data" to refer to information gathered to capture people opinions and views in order to get a better understanding of their motivations and barriers towards animal disease reporting.

We present a case study of smallholder reporting as part of passive surveillance for livestock diseases in a resource-scarce setting (Southern Bolivia). Bolivia is currently undertaking a considerable effort towards FMD eradication using the so-called "progressive pathway" for FMD control (PCP-FMD) (Anonymous, 2011). The macro-region of the Altiplano (high plateau) has recently been declared free without vaccination and an ongoing control programme is expected to eliminate virus circulation from the Amazon region by the end of 2013. The rest of the country is considered to be FMD-free with vaccination. As recognised by the World Organization for Animal Health (OIE), one of the main challenges faced by the Bolivian veterinary services in the context of FMD control in particular, but also in relation to other livestock diseases, is the strengthening of their surveillance system (Muzio Llado and Gonzalez Ortiz, 2008). Here, our aim is to conduct a comprehensive and systematic investigation of smallholders' characteristics, actions and practices relevant for livestock disease surveillance. This case study will be used to illustrate the application of mixed methods to achieve a more comprehensive description of surveillance systems for animal health that explicitly incorporates livestock keepers' actions and practices.

2. Materials and methods

2.1. Study setting

Bolivia has the third lowest Human Development Index (HDI) in America; most rural households in Bolivia keep livestock and are classified as poor (Klugman, 2010). FMD is the only livestock disease with an active surveillance programme in Bolivia. There is an ongoing voluntary vaccination programme for bovine rabies and voluntary control programmes for bovine tuberculosis and brucellosis in the main milk-producing areas. In pigs, classical swine fever (CSF) is believed to be present with the last outbreak reported in smallholding premises in 2007, but no official control programme is in place. Passive surveillance relies on field sensors accredited by the official veterinary services (OVS); although they are not bound by any type of licensing agreement, they are expected to communicate animal health events to OVS' veterinarians who are in charge of field investigations and are expected to be in constant contact with sensors in their area (Anonymous, 2006).

This study was carried out in the Department of Tarija, in Southern Bolivia, which has a range of different agro-ecological zones, from the high plateaux to the valleys,

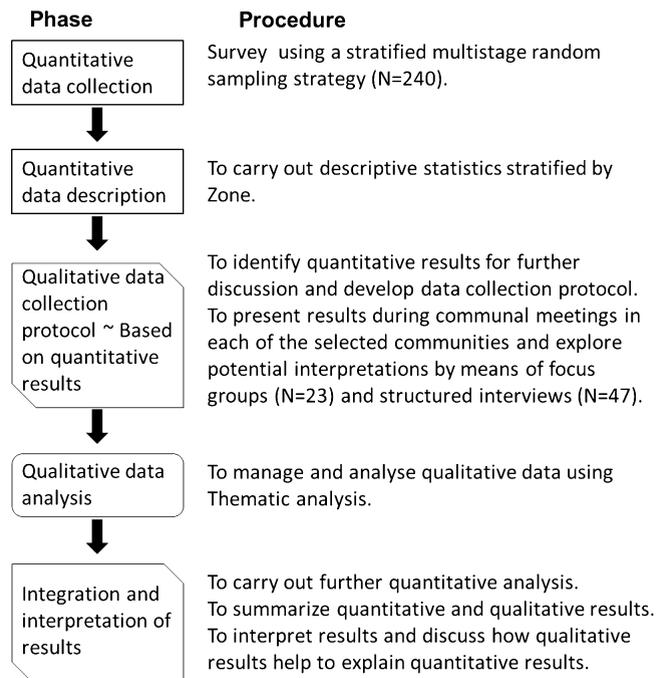


Fig. 1. Schematic overview of mixed method (explanatory) sequential design describing the phases used in this study. Rectangles represent phases of the quantitative strand; rounded rectangles represent phases of the qualitative strand and snip diagonal corner rectangle represent phases where quantitative and qualitative data are integrated.

and extending eastwards to the Chaco plains. FMD was last reported in Tarija in 2003. The department borders Argentina and Paraguay where FMD outbreaks occurred in 2006 and 2012 respectively.

2.2. Study design

We used a mixed methods explanatory sequential design (Creswell and Plano Clark, 2011) to gather and analyse quantitative and qualitative data in order to describe smallholding characteristics and smallholders' potential actions and barriers towards livestock disease reporting. Quantitative data were initially collected by means of a standardised questionnaire. Interviews and focus groups were then conducted in order to build upon information gathered in the initial questionnaire. The procedure and sequence of stages used are outlined in Fig. 1.

2.2.1. First stage: quantitative data collection

Between May and October 2009 a survey of smallholders was carried out in the study area using stratified multistage random sampling. An agro-ecological division into four strata was used: "Chaco plain", "Andean", "Central Valley" and "Sub-Andean" zones. For each stratum or zone a list of communities (administrative divisions typically composed of 20–200 households) was obtained. Communities ($n=952$) were classified as "urban" ($n=291$) or "rural" ($n=661$). Within each stratum, six rural communities were randomly selected and visited to explain the purpose of the study to the community leader. Upon agreement to carry out the investigation in the community, a sample frame of

households was developed and 10 were randomly selected and visited by an interviewer (local agricultural technician) accompanied by a member of the community proposed by the community leader.

The questionnaire was therefore administered to 60 households in each zone, allowing us to be 99% confident of detecting a certain household characteristic or activity if it was practiced by at least 8% of the households, assuming perfect sensitivity and specificity of the instrument used to ascertain the status of a household with respect to the practice.

In each selected household, the aim of the survey was explained, and verbal consent was requested prior to the start of the interview. The interviewer (HR) (same person for all study communities) administered a standardised questionnaire to collect information on livestock ownership, visits to the community by veterinary services, awareness of different notifiable diseases and most likely actions to be taken by the majority of smallholders in scenarios involving livestock morbidity and mortality (Table 1).

The questionnaire was developed in Spanish and administered following a detailed protocol, which includes a brief explanation describing the aim of the questionnaire and how to record answers given by participants. Both, protocol and questionnaire were piloted in two communities and minor adjustments were made accordingly. Copies of the questionnaire and protocol are available from the corresponding author upon request.

Ethical approval for this survey was obtained from the Royal Veterinary College Ethical Committee.

Table 1
Variables collected during the survey of smallholders ($n = 240$) and description of variables re-coded for multivariable analysis.

Survey		Data re-coding			
Variables	Description & how it was collected	Answer	Variable	Category	Description
Animal ownership	How many animals of the following species are owned by the household? Cattle Sheep Goats Pigs Llamas Poultry Donkeys Horses	Number of animals owned per species	<i>Cattle owned</i> ^a	Categorical (≤ 9 cattle; ≥ 10 cattle)	Cut-off was based on a statement repeatedly mentioned during focus group discussions: 'in order to receive technical support households should be affiliated to an institution and for this one should have at least 10 animals (cattle)'
			<i>Number of species owned</i> ^a	Species owned in the household: ●1 species ●2 species ●3 species ●4 species ●5 species ●6 species	Household were classified regarding how many different livestock species they owned (for how many of the following species they owned at least 1 animal: cattle, sheep, goats, pigs, poultry, llamas)
Frequency of visits from Official Veterinary Services	Last time veterinary services visited the community	Options given: ● less than a year ago ● more than 1 year but less than 2 years ago ● between 2 and 5 years ago ● more than 5 years ago	<i>OVS visited within the last year</i> ^a	Yes/No	OVS visited the community less than a year ago
Disease awareness	Have you heard about:		<i>Awareness of diseases</i>	Household member interviewed have heard of:	How many of the four noticeable diseases mentioned during the survey of which the interviewee is aware of ^c
	● Food and Mouth Disease (FMD) ● Bovine Rabies ● Bovine Tuberculosis (TB) ● Classical swine fever	Yes/No Yes/No Yes/No Yes/No		● 1 disease ● 2 disease ● 3 disease ● 4 disease	
Actions towards animal diseases	● Action(s) you would take if a new disease emerged in your animals ^c 'What would you do if a disease that has not affected your animals before presented for the first time in your animals?'	Scenarios were written to describe an animal health situation. A set of possible answers were written to facilitate recording, but possible answers were not read to the person answering the questionnaire. Possible answers included:	Answers 'would notify the OVS' and 'would ask/notify a private vet' were joined in one category called: Communicate outside the community ^b	Yes/No	This was based on the fact that private vets are considered part of the Surveillance National System and are expected to report any suspected case
	● Action(s) most people in the community would take if a disease with high mortality affected their animals: 'What would most people in the community do if almost all their animals die within one week?'	● Would communicate to other animal owners in the community ● Would let the animal health worker in the community know ● Would ask/communicate a private vet ● Would report to the OVS ● Mention other option (specify)	Answers 'communicate to other animal owners in the community' and 'would let the animal health worker in the community know' were joined in one category called: Communicate within the community ^b	Yes/No	This was based on the assumption that animal health workers would communicate with other animal owners

Survey of smallholders was carried out between May and October 2009 in Southern Bolivia ($n = 240$ smallholders from 4 agro-ecological zones (60 households per zone)).

^a 'Cattle owned', 'number of species owned', 'OVS visited within the last year' and 'awareness of diseases' were the predictor variables.

^b 'Communicate outside the community' and 'Communicate within the community' were the outcome variables in the multivariate analysis.

^c Scenarios considered.

2.2.2. Second stage: quantitative data description

Descriptive statistics were obtained, by stratum, for variables captured in the survey (Table 1) and weighted according to total number of households in the community. Key variables to be presented to the community at later stages of the research were identified by discussion among four members of the research team, comprising two veterinary epidemiologists (GL, JG), a sociologist (MEB), and a local agricultural technician (HR).

2.2.3. Third stage: qualitative data collection protocol

Survey results were presented by the interviewer and a local qualified sociologist (MEB), with previous experience in rural communities, during one of the regular, monthly meetings held at each community ($n=24$). The two members of the research team presenting the results were local people in order to encourage smallholders' trust. A series of topics were presented with 2 or 3 open questions following the presentation of survey results relevant to each topic (Table 2). Questions were open-ended, with the aim of generating rich descriptive narratives. Approximately 15 min were spent upon each topic with the sociologist acting as a facilitator for the discussion, ensuring that it was not dominated by one person and encouraging participation from most people present. Discussions were recorded and field notes were taken. In addition, structured interviews with 1 or 2 purposively selected community members were carried out, individually, by the sociologist at the end of each meeting and lasted a maximum of 45 min. The interviewees were selected by the meeting participants, however, the researchers suggested that the selected person(s) should be knowledgeable about the community, respected by its residents and if possible should not be the community leader. All communities were visited for qualitative data collection between June and October 2010.

2.2.4. Fourth stage: qualitative data management and analysis

The qualitative phase involved analysing data using Thematic Analysis, which provides “rich and detailed, yet complex account of data” (Braun and Clarke, 2006). As it is not allied to a specific theoretical framework, it is a flexible approach that can be used to examine a variety of issues. Interview and focus group transcripts were repeatedly read in order to become familiar with the participants' accounts of livestock surveillance. Following this, codes were generated to capture the salient features of the data and developed into themes representing the entire data set. This is an inductive approach, firmly grounded in the participants' data and not influenced by theoretical or researcher preconceptions.

The concepts of validity and reliability in qualitative research differ from the framework traditionally applied to quantitative work (Smith, 2008). Qualitative research aims to provide an in-depth investigation of the phenomena under consideration; as such a smaller sample size is normally used. Validity is ensured by employing inter-coder reliability.

The first step of qualitative analysis involved the reading and re-reading of the transcripts by four members of the research team, in order to become familiar with the data. Then, codes for each topic were identified through interactive discussions between members of the research team.

In the next step, codes were applied systematically to the transcripts and the data were rearranged according to codes and communities in matrices. A member of the research team (MEB) conducted the initial coding and thematic development. An audit was then conducted by two other members of the research team (GL, HR), in order to ensure validity and consistency of interpretation. Disagreements were discussed until consensus was reached and initial themes were reviewed. Codes and reviewed themes were translated at this stage and final themes were

Table 2

Topics selected for presentation to the communities and questions used to gather qualitative data during focus groups and structured interviews carried out in 23 rural communities in Southern Bolivia, June–October 2010.

Topic	Questions asked
Frequency and reasons of OVS visiting the community	<ul style="list-style-type: none"> • It seems that OVS visit some communities more than others; do you think this is accurate? • Why do you think this happens? • What is the situation in this community? • Would it be positive for the community if this changed?
Awareness of noticeable diseases	<ul style="list-style-type: none"> • Why do you think the majority have heard about Foot and Mouth disease but far less people know about classical swine fever? • Do you think is true that there is no rabies or Foot and Mouth disease in the central valley, Andean and Sub-Andean zones?
Actions towards a disease with high mortality rate	<ul style="list-style-type: none"> • How would you interpret that in some zones animal owners give notice to a veterinarian and in other zones to animal health workers? • Which might be the reasons for those differences? • Why do you think that only few people would be willing to give notice to the OVS? • What would people normally do in this community?
Actions towards incursion of an emerging disease in the household	<ul style="list-style-type: none"> • How would you interpret that in these situations animal owners in some zones give notice to the rest of the community and in other zones each household deal with it by themselves? • What are the reasons for those differences? • What do people normally do in this community? • Why do you think that only few people would be willing to give notice to the OVS?

Table 3

Revised codes and themes identified as factors influencing presence of OVS in the community, awareness of noticeable diseases, actions taken towards animal diseases and barriers for reporting to the OVS. Codes and themes were identified through interactive discussions using Thematic Analysis.

Topic	Codes	Code definition	Theme(s)
Presence of OVS in the community	Distance from the OVS offices to the community	Location of the community in relation to the OVS offices	Community attributes
	Accessibility to the community	Topography and state of the roads leading to the community	
	Political interest	Community relationship with the party in power	
	Community profile	The main livelihood of people in the community (e.g. Livestock orientated, agriculture orientated, etc.)	
Awareness of noticeable diseases	Had experienced the disease in their animals	Animals in the household and/or community have had the disease	Vivid experience
	Knowledge transmitted through generations	Past generations experienced the disease in their animals and told the younger generations of their experiences	Theoretical awareness
	Ownership of the susceptible species	Someone in the household owns/have owned the species that get affected by the disease	
	Dissemination by media and or governmental institutions	There is either a vaccination campaign for the disease or government programmes to raise awareness	
Barriers for reporting to OVS	Activities perceived as important	Activities carried out by veterinary services perceived as important by smallholders	Institution credibility • Lack of communication
	Smallholders past experience with animal related events	Experience of smallholders in previous campaigns and/or when they contacted the OVS	
	Presence & lack of presence of the OVS in the community	Presence and lack of engagement from the OVS perceived by smallholders	
Factors influencing actions towards animal diseases	Accessibility to the community	Topography and state of the roads leading to the community	Community attributes
	Community's capacity for organisation	Capacity of organisation and cooperation between community residents	
	Technical resources available	Presence of animal health worker in the community or a private vet nearby.	
	Household location	Geographical location of the household within the community	Household resources and location
	Affiliation to an institution	Someone in the household being affiliated to a union or institution	
	Household assets	Money or goods that can be used to obtain technical assistance and/or treatment	

defined through interactive discussions with the rest of the research team (Table 3).

2.2.5. Fifth stage: integration and interpretation of results

The heterogeneity across study zones of variables considered as potential predictors for communication of disease events within and outside the community (outcome variables) (Table 1) was explored using likelihood ratio tests with community as random effect. For those predictors that were significant, Tukey's post hoc comparisons between zones were carried out. Then, the extent to which each predictor variable was associated with each of the individual outcomes ('Communicate outside the community' and 'Communicate within the community'; Table 1) was determined using a multivariable logistic regression. To evaluate the scenario 'action(s) you would take if a new disease emerged in your animals' zone was included in all models as fixed effect and community as a random effect. For the scenario 'actions most people in the community would take if a disease with high mortality affect their

animals' data was aggregated at community level and zone was included in all models as fixed effect.

Statistical analysis was performed in R 2.14.1 using packages latticeExtra, lme4 and multicomp.

3. Results

3.1. Communities and household studied

The survey was carried out in 240 households from 24 communities (6 communities per agro-ecological zone). Results were presented during communal meetings in 23 communities – for one community it was not possible to get any time during the meeting, therefore in this instance only the structured interviews were carried out.

The four zones were highly heterogeneous with respect to community size (range: 10–300; median: 48 households), number of animals per household (Fig. 2) and number of species kept in the household – most likely value was 5 species for Chaco plain, 3 for Central Valley, 4 for Andean, and 1 for Sub-Andean.

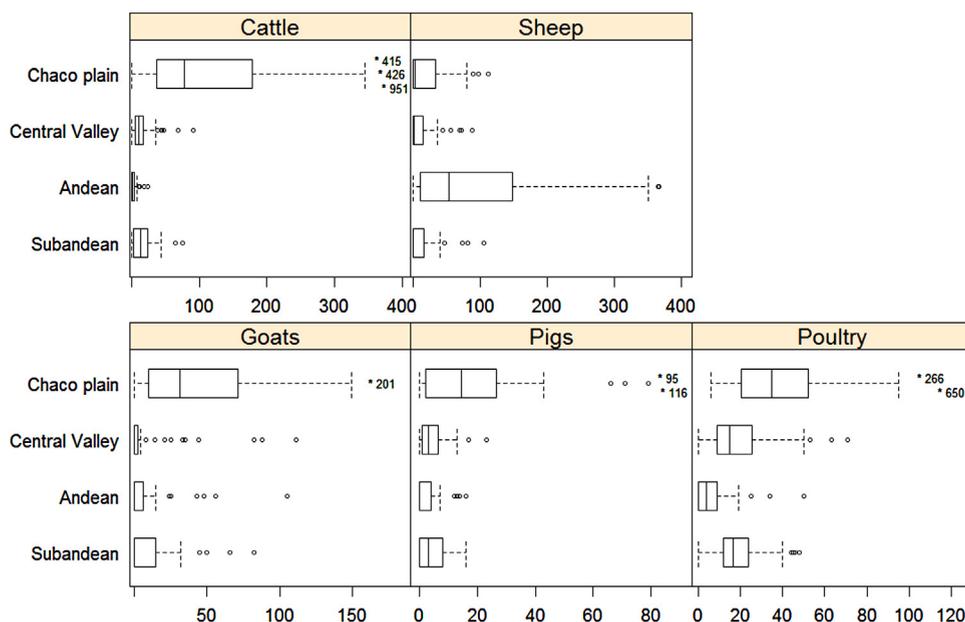


Fig. 2. Box plot showing animal ownership of the 5 main species kept across zones. Information collected during the household survey ($n=240$) carried out between May and October 2009.

3.2. Frequency of visits from Official Veterinary Services to the communities

The frequency with which the OVS visit the communities varied markedly across zones. While over two thirds of participants in the Central Valley stated that the OVS had visited the community within the last year, less than 8% acknowledged this in the Sub-Andean zone (Table 4). Community attributes was the theme identified from the community meeting discussions as the main potential factor influencing OVS visiting the community (Table 4). This theme encompasses characteristics related to geographical constraints; community relationships with the party in power and the main livelihood of people in the community (Table 3).

Geographical characteristics such as the location of the community in relation to the OVS offices, topography and accessibility by road were perceived as important influences on the frequency of the OVS visits in communities. These issues were raised repeatedly during the meeting discussions in the Chaco Plain, Andean and Sub-Andean zone. They were perceived as particularly important by some of the most isolated communities in these zones, who perceived themselves as neglected compared to other, geographically convenient, communities. This is reflected in the quotations below:

“Governmental institutions do not visit the community frequently because they consider it far away; they go to the communities that are closer” (Andean zone – group discussion)

“... access to the community is difficult. . . long distance, lots of curves and mountains, narrow paths and lack of

bridges. . . and this has a big influence” (Sub-Andean – group discussion)

Conversely, in the Central Valley location and access to the community was rarely mentioned. Here having a small number of animals was perceived as a central issue, with those keeping fewer livestock feeling ignored in favour of those communities with a greater output:

“... they don’t come here because we are not big producers in this community” (Central Valley – group discussion)

“they go where there are more animals, for example in the Chaco plain there is plenty of cattle, here we have few animals. . .” (Central Valley – group discussion)

Political interest was a factor frequently mentioned in all zones. The relationship between the local government and the community was considered to be a major influence in the prioritisation and allocation of resources, including visits by the OVS.

“Some communities are visited more often because of political interest, I mean if the same party that wins the municipal government won in the community, then the community gets some benefits. . .” (Andean zone – group discussion)

“Political interest has a big weight. . . if the party in power received votes from a community, this community will receive support,” (Chaco plain – group discussion)

3.3. Awareness of notifiable diseases

Almost all participants had heard about FMD and the majority had heard about Rabies. Fewer participants had heard about Tuberculosis and CSF (Table 5). Overall, no

Table 4

Presence of OVS in the community according to participants interviewed during a survey of smallholders ($n=240$) carried out between May and October 2009, and themes identified as factors influencing OVS presence from qualitative data gathered during focus groups and semi-structured interviews in 23 rural communities in Southern Bolivia between June and October 2010.

Last time the official veterinary services visited the community	Zone				Themes identified as factors influencing presence of veterinary services in the community:
	Chaco plain	Andean	Central Valley*	Sub-Andean*	
Visited within the last year	26.1%	17.3%	64.1%	7.9%	•Community attributes

Overall, a significant difference in frequency of OVS visits was found between zones ($P=0.044$).

* Post hoc comparison showed a significant difference between the Sub-Andean zone and Central Valley ($P=0.03$).

significant difference in awareness of notifiable diseases (or lack of it) was found between zones ($P=0.75$). Two themes were identified as factors influencing 'awareness of notifiable diseases': Theoretical awareness and vivid experiences. (Table 3)

Theoretical awareness relates to knowledge acquired through third parties, such as government awareness programmes, vaccination campaigns or knowledge passed through generations. It highlights that people are aware of the disease even though they have not seen it themselves and accentuates the importance of communication about diseases:

"Years ago Foot and Mouth Disease was present in the community and elderly people talk to us about it" (Andean zone – group discussion)

"We are aware of Foot and Mouth Disease because there are campaigns for the disease, contrary to classical swine fever for which there hasn't been any campaign. . ." (Central Valley – group discussion)

In contrast, vivid experiences are the animal owners' direct experience of the disease either in their own animals or through someone in the community, where they see the disease first hand:

"Rabies is present in the community, last year some animals were affected. We found three bats in the mountains and we sent them to be analysed and they were rabies carriers. . ." (Sub-Andean zone – group discussion)

"Foot and Mouth disease was present in the community 15 years ago. . ." (Andean zone – interview)

3.4. Actions towards animal diseases

Most participants agreed that in the event of a new disease emerging, they would not inform the OVS. This was the case when interviewees were asked about what they would do themselves and what most people in the community would do (Table 6). Not reporting to OVS is the most likely action in all zones, but the case of the Andean and Sub-Andean zones is remarkable: none of the 120 people interviewed believed that in the event of a new livestock disease the most likely action would be reporting to the OVS.

Poor institutional credibility was the main theme found for low reporting across all zones. As illustrated by the statements below, there is a lack of trust in the efficiency of the OVS mainly related to past experiences and lack of OVS presence in the community. Community members often believe that OVS are disinterested in their problems and not motivated to help:

"It would be great if when we notify the authorities about animal diseases that they'd bother to come to the community" (Chaco plain zone – group discussion)

"We don't report to the veterinary services because they won't come anyway" (Sub-Andean zone – group discussion)

"The veterinary services just visit the community once a year, if we ask them to come they never do. . . if we wait for them to help us, animals would die, they always say that there isn't a car available to come, so the community doesn't trust them" (Central Valley – group discussion)

Table 5

Awareness of noticeable diseases by participants interviewed during a survey of smallholders ($n=240$) carried out between May and October 2009 and themes identified as factors influencing disease awareness from qualitative data gathered during focus groups and semi-structured interviews in 23 rural communities in Southern Bolivia, between June and October 2010.

Had heard and/or known about the disease	Zone				Themes identified as:
	Chaco plain	Andean	Central Valley	Sub- Andean	
Foot and mouth disease	96.1%	94.5%	100.0%	97.8%	
Rabies	89.1%	72.2%	99.0%	96.9%	
Tuberculosis	8.5%	58.3%	41.8%	38.9%	
Classical swine fever	88.6%	34.1%	64.8%	58.6%	•Vivid experience
<i>Number of diseases that had heard about</i>					
None	0%	1.9%	0%	2.2%	•Theoretical awareness
1 disease	1.4%	12.0%	0%	0.9%	
2 diseases	21.4%	26.5%	28.3%	33.5%	
3 diseases	71.5%	42.3%	37.8%	29.3%	
4 diseases	5.7%	17.3%	33.9%	34.1%	

Table 6

Actions towards animal diseases of participants interviewed during a survey of smallholders ($n=240$) carried out between May and October 2009 and themes identified as (i) reasons for not reporting to the OVS and (ii) factors influencing actions towards animal diseases from qualitative data gathered during focus groups and semi-structured interviews in 23 rural communities in Southern Bolivia between June and October 2010.

Action you would take if a new disease affects your animals ^a	Zone				Themes identified as:
	Chaco plain	Andean	Central Valley	Sub-Andean	
Report to the OVS	9.7%	0.0%	17.3%	1.5%	Barriers for reporting to the official veterinary services ●Institutions credibility (perceived by smallholders)
Communicate outside the community ^b	61.6%	53.3%	66.6%	45.0%	
Communicate within the community ^b	18.3%	75.0%	75.0%	83.3%	Factors influencing actions towards animal diseases
Action(s) most people in the community would take if a disease with high mortality affects their animals ^a	Chaco plain	Andean	Central Valley	Sub-Andean	●Community attributes
Report to the OVS	3.9%	0.0%	18.4%	0.0%	●Household resources
Communicate outside the community ^b	25.0%	35.0%	25.0%	35.0%	
Communicate within the community ^b	41.6%	83.3%	86.6%	91.6%	

^a Answers given are not mutually exclusive.

^b See Table 1 for explanation of data re-coding.

In addition, lack of communication between veterinary services and smallholders appears to be a common problem that leads to misunderstandings and a lack of credibility in the OVS. Community members often believe the actions of the OVS do more harm than good:

“Some people don’t even want the vaccine given by the government because on one occasion some animals died and others aborted after the vaccine. . . one cow didn’t get pregnant for two years. . . we communicate between us. . .” (Andean zone – group discussion)

“There is a belief that vaccines are hazardous for the animals. . . a farmer who had his cows vaccinated said that they got fever afterwards, the same happens to the cows of other owners, so people don’t trust treatments given by the government. . .” (Central Valley – group discussion)

‘The government provided FMD vaccines without considering that this disease is not common here. There are diseases happening more frequently, such as blackleg and parasites. . . animals die of those diseases if they haven’t been vaccinated’ (Central Valley – group discussion)

Communication outside the community in the event of a new livestock disease is more likely than communication to the local OVS (Table 6). Disease events are very likely to be communicated within the community, with one exception: the Chaco plain where less than 1 in 5 households recognised that they would report them within the community (around three quarters would do so in the other zones). Two themes were identified as reasons for such differences: community attributes and household resources (Table 3). The former encompasses the characteristics of the community. For example the community’s accessibility plays an important role in the likelihood of seeking assistance or communicating a disease event outside the community.

Furthermore, the size of the community and distance between households is an important factor in communicating a disease event within the community. This was expressed in the Chaco plain where more land is available and in most communities households are dispersed:

“Distance between households is a limitation here, so when a disease affect your animals one solves it alone. . . communities where households are close together can communicate easier when a disease emerges” (Chaco plain – group discussion)

Intra-community relationships and level of organisation within the community are central to the likelihood of disease communication within the community, as well as their propensity to try and work together towards a solution. This is also influenced by the magnitude of the disease spread:

If just one or two animals die one wouldn’t notify the animal health worker or the vet, but if the deaths are one after another and in various households we know an outbreak is happening, so we call for a communal meeting to decide what to do” (Andean zone – group discussion)

“It would be important a better organization within the community. . . there is a lack of organization because of envy between us” (Andean zone – interview)

Finally, in those communities with technical resources available either within the community or nearby (such as an animal health workers or a private vet) people would communicate a disease event to them. However, not every community has this option.

“We don’t have a vet nearby the community; maybe other zones have accessible vets because they have more animals” (Central Valley – group discussion)

Table 7

Results of mixed effect models evaluating actions animal owners from would take towards an emerging disease and a disease with high mortality in southern Bolivia.

Scenario	Variable	OR (95% CI) ^c	P-value
<i>Action(s) you would take if a new disease affects your animals</i>			
Communicate outside the community ^a	Cattle owned	0.81 (0.42–1.57)	0.54
	Number of animal species owned	1.19 (0.95–1.49)	0.13
	Awareness of disease	1.34 (0.97–1.86)	0.07
	Frequency of veterinary services visits	1.90 (0.57–1.97)	0.84
Communicate within the community ^a	Cattle owned	0.74 (0.33–1.66)	0.47
	Number of animal species owned	1.09 (0.82–1.46)	0.57
	Awareness of disease	0.95 (0.63–1.42)	0.81
	Frequency of veterinary services visits	1.99 (0.86–4.64)	0.11
<i>Action(s) most people in the community would take if a disease with high mortality affects their animals</i>			
Communicate outside the community ^b	Cattle owned	0.92 (0.81–1.05)	0.24
	Number of animal species owned	1 (0.97–1.03)	0.87
	Awareness of disease	0.97 (0.89–1.07)	0.63
	Frequency of veterinary services visits	1.07 (0.98–1.17)	0.1
Communicate within the community ^b	Cattle owned	0.97 (0.82–1.17)	0.82
	Number of animal species owned	1.05 (1.01, 1.11)	0.008
	Awareness of disease	1.05 (0.93–1.18)	0.39
	Frequency of veterinary services visits	1.02 (0.92–1.14)	0.67

^a All models include community as random effect and zone as fix effect.

^b All models include zone as fix effect.

^c The extent to which each variable is associated with each scenario.

Household resources and location encompass the geographical location of the household within the community and household assets (Table 3). The latter can be used to pay for technical assistance or treatment, but also used in order to be affiliated to a local farmers' union or governmental organisation (in the case owning cattle), which in turn will allow the household to receive technical support. This support is dependent upon sufficient ownership and resource, and deemed to confer an advantage:

"To receive technical support one should be affiliated to an institution and for this you should have at least 10 animals (cattle). . . there are some people that have fewer animals and they don't have access to a vet. . . so the major benefit is for the ones that have more animals" (Chaco plain – group discussion)

Multivariable analysis of the action(s) that animal owners would take if a new disease affected their animals showed a marginally significant association between awareness of diseases and reporting outside the community ($P=0.07$), suggesting that having previous knowledge of existing diseases would make people more likely to communicate a new disease.

Communities in which households tend to keep a range of different species are more likely to communicate within the community than those where households are more specialised ($P=0.008$). Table 7 shows the results of the multivariable analysis.

4. Discussion

Information generated by epidemiological surveillance is the basis for allocation of resources and prioritising of disease control interventions (Jones et al., 2008; FAO, 2011; Halliday et al., 2012). In countries like Bolivia, where the surveillance system relies, to great extent, on animal owners for early detection of animal diseases, it becomes

critical to understand not only the likely actions to be taken by animal owners to cope with emerging and endemic diseases, but also possible reasons for taking such actions. Through greater understanding there is more scope for surveillance systems to be enhanced.

In this study we combined a large-scale probabilistic household survey with the systematic collection and analysis of complementary qualitative data during presentation of survey results. This allowed us to expand upon the quantitative data to build a fuller picture of disease reporting in the study area of Southern Bolivia. By using mixed methods we have been able to identify likely actions taken by smallholders when facing livestock diseases, to formally assess how common such actions are and how they vary across the study area and across groups of smallholders. Crucially, we have also been able to gain insight into possible reasons for these actions.

In Bolivia, there is a clear pathway for livestock disease reporting where feedback should flow back following the same path (Anonymous, 2006). However, this rarely happens; willingness to report is very low among smallholders and information rarely reaches even the field sensors. The main barriers to disease reporting are lack of institutional credibility and misalignment between OVS and livestock keepers' disease priorities. New technologies such as smart phones have been piloted as a means to facilitate exchange of information between smallholders and OVS in developing countries (Thinyane et al., 2010). Although these technologies are worth to considering, they do not tackle more fundamental issues for disease reporting such as institutional credibility or conflicting priorities. They represent an attempt to solve the problem, without looking at the causes. The perception that some OVS' activities are actually detrimental to animal health raises serious concerns and highlights the need for effective dialogue with smallholders. This could enhance disease awareness, which we have shown to be positively associated with

reporting and could potentially improve the performance of the surveillance system by increasing its timeliness and sensitivity. Similarly, lack of trust in governmental bodies and dissatisfaction with post reporting procedures are known detrimental factors for animal disease reporting (Palmer et al., 2009; Elbers et al., 2010).

In interpreting our results in relation to the lack of support by the OVS, it should be taken into consideration that, as in other developing countries, it is common for rural households in Bolivia to receive external aid during government campaigns and from NGOs. The research team may have been considered as an opportunity to obtain external assistance and as a result the lack of support received by the OVS might have been overstated.

The Bolivian surveillance system should be improved in view of controlling and eradicating FMD, and this has been acknowledged by the OIE (Muzio Llado and Gonzalez Ortiz, 2008). The issues described here with regard to disease reporting are shared across developing and developed countries and apply to both human and animal diseases (Elbers et al., 2010; Ellis-Iversoen et al., 2010; Chan et al., 2011; Delgado et al., 2012; Halliday et al., 2012). Improving timeliness and willingness of smallholders to report is challenging and there cannot be a one size fits all system. Individual and local characteristics should be understood and taken into consideration when planning and enhancing surveillance systems. Understanding local characteristics as well as people motivation and barriers to report can only be gained by means of well-designed and executed qualitative field research. In recent years, “participatory approaches” have become popular in the veterinary field and pieces of “participatory epidemiological research” are often presented as qualitative research (Catley et al., 2012). However, participatory research is often criticised as a supposedly qualitative approach that is rooted on positivist assumptions (Green and Thorogood, 2007). In our opinion, the epistemology and methodology used in participatory research in animal health often lacks clarity and the categorization of research as “participatory” does not imply that the focus of the research is on interpretation and understanding of livestock keepers’ meanings. To be able to assess whether the insights claimed to be gained are sustained by the methods used, such studies should clearly state whether the research problem is approached as a quantitative or qualitative question, or, as is the case here, both.

By combining sound quantitative and qualitative research into a “mixed methods” framework we have gained a greater understanding of smallholder disease reporting than would have been achieved by either approach alone. Although different mixed methods designs can be used across different disciplines in a relatively standard fashion, it is important to define the theoretical position to be adopted during the qualitative phase. Each theoretical framework has different assumptions regarding the nature of the data and the meaning of what the participant has said, and this will influence the data analysis and interpretation. In our study we used an inductive approach, which is grounded in the participants’ data.

A limitation of the explanatory sequential design used was the amount of time needed to implement both phases. On the other hand, this sequential approach allowed us to design the qualitative component based upon results obtained during the quantitative phase, thus focusing on the issues highlighted as important by the communities themselves. As a result, both components were well aligned and it was possible to focus the qualitative phase on obtaining rich information on a small number of key issues.

The insights gained from this study should inform the enhancement of passive surveillance activities as part of the progressive control of FMD in Bolivia. We propose that similar research questions would benefit from a mixed methods approach integrating both quantitative and qualitative methods.

Competing interest

The authors declare that they have no competing interest.

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