"Mapping the link between socio-economic factors, autistic traits and mental health across different settings"

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Abstract

Autistic individuals experience higher rates of externalising and internalising symptoms that may vary with environmental factors. However, there is limited research on variation across settings that may highlight common factors with globally generalisable effects.

Data was taken from two cohorts: a multinational European sample (n= 764; 453 Autistic; 311 non-Autistic; 6-30 years), and a South African sample (n=100 non-Autistic; 3-11 years). An exploratory factor analysis aggregated clinical (Verbal Comprehension and Perceptual Index), adaptive traits (Vineland Adaptive Behaviour Scale) and socio-economic variables (parental employment and education, home and family characteristics) in each cohort separately. With regression, we investigated the effect of these factors and autistic traits on internalising and externalising scores (measured with the Strengths and Difficulties Questionnaire).

Cohorts showed similar 4-factor structures (Person Characteristics, Family System, Parental and Material Resources). The "Family System" factor captured family size and maternal factors and was associated with lower internalising and externalising symptoms in both cohorts. In the European cohort, high autistic traits reduced this effect; the opposite was found in the South Africa cohort.

Our exploratory findings from two separate analyses represent consistent evidence that Family System is associated with internalising and externalising symptoms, with a context-specific impact in persons with high autism traits.

Lay Abstract

Autistic individuals are more likely than non-autistic individuals to experience a mental health condition in their lifetime, and this includes externalising and internalising symptoms. We know very little about how different environments and family conditions impact these symptoms for autistic individuals. Improving our understanding of these relationships is important so that we can identify individuals who may be in greater need of support. In this paper, we seek to improve our understanding of how environmental and family conditions impact externalising and internalising symptoms in autistic and non-autistic people. To do this, we conducted analyses with two cohorts in very different settings - in Europe and South Africa - to ensure our findings are globally representative.

We used advanced statistical methods to establish environmental and family conditions that were similar to each other, and which could be combined into specific "factors". We found that four similar "factors" could be identified in the two cohorts. These were distinguished by personal characteristics and environmental conditions of individuals, and were named: Person Characteristics, Family System, Parental and Material Resources. Interestingly, just "Family System" was associated with internalising and externalising symptoms, and this was the same in both cohorts. We also found that having high traits of autism impacted this relationship between Family System and mental health conditions with opposite directions in the two settings. These results show that characteristics in the Family System are associated with internalising and externalising symptoms, and autistic persons are particularly impacted, reinforcing the notion that family stressors are important to consider when implementing policy and practice related to improving mental health of autistic people.

Introduction

Common internalising and externalising symptoms in autism

Globally, 1 in 132 people are estimated to be autistic, with little regional variation (Baxter et al., 2015). Beyond the clinically defining difficulties in the social domain and repetitive behaviour, 80% of autistic adults experience a mental health condition during their lifetime, including externalising and internalising symptoms (Lai et al., 2019; Lever & Geurts, 2016).

Individuals with high levels of autistic traits are at higher risk of these symptoms and of the associated conditions (e.g., depression, anxiety, conduct problems, hyperactivity) than the general population (Beck et al., 2020; Gray et al., 2012). This can lead to poorer outcomes in education and social status, unemployment and social isolation (Eilenberg et al., 2019). To understand the individual traits and environmental factors that covary with internalising and externalising symptoms, studies in the general population have linked high prevalence of externalising/internalising symptoms to physical health, temperament and attachment, and family size, parental and material resources (Kim & Kim, 2017), but less is known about how autistic traits interact with multifactorial socio-economic risk (Flouri et al., 2015; Midouhas et al., 2013).

People with higher levels of particular traits that present increased risk for developing internalising and externalising problems, such as cognitive inflexibility (Carter Leno et al., 2022; Ozsivadjian et al., 2021), and reduced verbal abilities (Bauminger et al., 2010), that may respectively increase post-stress rumination, persistent negative thoughts (Carter Leno et al., 2022), spirals of anxiety (Ozsivadjian et al., 2021), and delay help-seeking (Bauminger et al., 2010). Socio-economic factors, such as low income, poverty, parental education and occupation negatively impact mental health in the general population (Reiss, 2013). Similar patterns affect autistic people too (Aishworiya et al., 2021; Midouhas et al., 2013; Simonoff et al., 2013), however, some relationships may be unique to autistic populations (e.g., neighbourhood deprivation and special school attendance predict improvement over conduct problems in autistic teenagers; Simonoff et al., 2013), and great heterogeneity exists between autistic people both in terms of traits and outcomes (Lai et al., 2019; Levy & Ebstein, 2009). Therefore, two points need to be explored: first, the aggregation of multiple

socio-economic variables that impact mental health, occur in parallel and are closely associated in real life. Second, the interplay between the multifactorial nature of socio-economic factors and varying autistic traits. Multifactorial influences are particularly important, given the evidence that income, commonly used as proxy for socio-economic status, is not the best predictor across contexts, and that factors such as family size, composition and parental characteristics play a role in different settings (Bentenuto et al., 2021; Geetha et al., 2019; Schiller et al., 2021; Smith & Elder, 2010). With context-specific factors and traits capturing variation within study populations, it becomes possible to start exploring hypotheses on why people on the autism spectrum from low resource settings gain limited access to support (Eilenberg et al., 2019; Lockwood Estrin et al., 2021) and how this impacts their mental health outcomes (Doherty et al., 2022).

In this paper, we conduct an exploratory analysis of personal and environmental factors from two large cohorts, and estimate their impact on externalising and internalising symptoms, as measured by the Strengths and Difficulties Questionnaire (SDQ; Vostanis, 2006) in people with varied levels of autistic traits. Whilst these two cohorts are analysed separately, we critically compare findings from the two cohorts in the discussion and argue that the importance of these results lie in similarities and differences - as findings from global samples may not necessarily generalise to each other. These two cohorts were chosen for their shared unified protocol as part of AIMS-2-TRIALS, but also because they represent a high-income and a low-and-middle income setting. The majority of autism research to-date has focused on samples recruited in high-income, Western settings with reduced findings generalisability and limited understanding of context-specific environmental and personal influences, calling for greater diversity and a more global perspective in autism research (de Leeuw et al., 2021; de Vries, 2016; Durkin et al., 2015).

The first cohort comes from the Longitudinal European Autism Project (LEAP; Loth et al., 2017), the second comes from the Safe Passage study (SP), recruited from a neighbourhood with high levels of socio-economic disparity in Cape Town, South Africa (Dukes et al., 2014). The available socio-economic indexes differ across settings (e.g., in SP, perinatal variables such as maternal body weight, smoking and preterm birth were recorded to reflect the specific risk factors in the region), therefore we conducted two separate exploratory Factor Analysis (a statistical method that aggregates

variables based on their inter-correlations; Dovgan et al., 2019; Glod et al., 2017; Keefer et al., 2020) on the personal and socio-economic variables for the two cohorts. A strength of using both personal and environmental variables is to empirically test whether these variables that have been found to impact each other (e.g., education and finances associated with adaptive behaviour; Aishworiya et al., 2021) are also inter-correlated in these contexts. Via multiple linear regression, we used the newly generated factors in interaction with a continuous measure of autistic traits (with the advantage of improved statistical power and parsimony of parameters compared to a categorical predictor such as autistic/non-autistic; Kim et al., 2019; Lazic, 2008; Pickles & Angold, 2003) to estimate their impact on externalising and internalising symptoms. We expect that in people with high autistic traits, the risk determined by environmental factor may be greater and relate to distinct dimensions, for example larger families may provide larger support networks against poorer mental health outcomes in the general population, but an autistic person in a large family may experience the opposite effect because dispersal of family resources may translate in reduced access to support for a person who is more at risk of poor mental health. By exploring these factors and their impact on mental health outcomes across two settings (Western Europe and South Africa), we aim to capture meaningful variance across settings without losing validity for either setting (Wuermli et al., 2015).

Method

Participants and Samples

Cohort 1: Longitudinal European Autism Project

Study design and setting

This analysis includes the demographic data relating to the socio-economic status of 764 participants of Wave 1 of the Longitudinal European Autism Project (LEAP; for a description of the design and rationale of the study, see Loth et al. 2017), of whom 453 were Autistic, and 311 non-Autistic (for an in-depth clinical characterisation, see Charman et al., 2017). Volunteer participants to Wave 1 were recruited across 6 autism specialist centres in 4 countries (United Kingdom, The

Netherlands, Germany, Italy) from existing volunteer databases, research cohorts, local clinical referrals, special needs/mainstream schools, local communities. Participants inclusion criteria included existing clinical diagnosis of ASD (autistic group) and age between 6 and 30. Participants with an existing diagnosis were assessed with the Autistic Diagnostic Observation Schedule (ADOS) and Autistic Diagnostic Interview-Revised (ADI-R) by qualified psychologists. Non-autistic volunteers were excluded on the basis of high scores on a specific measure of autistic symptoms, and/ or a diagnosis of a psychiatric disorder. The study was carried out upon approval of national and local ethics review boards at each study site. LEAP is currently ongoing (Wave 3).

Questionnaires

Measures clinical characteristics included the Vineland Adaptive Behaviour Scales-2nd Edition (VABS-II; Sparrow et al., 2005) - a semi-structured parent/caregiver interview assessing adaptive behaviour -, the Verbal Comprehension (VCI) and Perceptual Reasoning Index (PRI) - calculated from the Wechsler Abbreviated Scales of Intelligence-Second Edition (WASI-II) / Wechsler Intelligence Scale for Children (WISC) / Wechsler Adult Intelligence Scale (WAIS; Wechsler, 2003, 2008) standardised across sites. The Autistic Quotient (AQ; Auyeung et al., 2008; Baron-Cohen et al., 2006; Woodbury-Smith et al., 2005), a widely used questionnaire with good sensitivity and specificity (Allison et al., 2012; Kurita & Koyama, 2006) was used to assess autistic traits. The Strength and Difficulties Questionnaire (SDQ) - a 25-item parent-report screening questionnaire focusing on conduct problems, hyperactivity, emotional symptoms, peer problems, and pro-social behaviour, including two subscales, for externalising and internalising problems (Goodman, 1997) - was used to assess mental health. See Table 1 for the distribution of these variables across the whole cohort.

Table 1: sample size, sex ratio and average age of Cohort 1, plus descriptive statistics of the continuous variables

Cohort 1 (LEAP)			
Variabl	Mean	Standard	Range

e		Deviation	
N	764 (311 autistic)		
N Females (M:F)	230 (3.30:1)		
Age	16.89	5.87	24.90
Strength and Difficulties Questionnaire Externalising	6.82	20.30	119.00
Strength and Difficulties Questionnaire Internalising	7.27	21.12	105.97
Autistic Quotient	73.00	4.69	18.00
Verbal Comprehension Index	98.96	4.20	18.00
Perceptual Reasoning Index	100.13	18.78	107.00
Vineland Adaptive Behaviour Scale	74.00	29.02	132.00
Income Range (Median)	£ 30k - 39k		

[insert Figure 1]

Figure 1: Values and percentage distribution of the demographic variables of Cohort 1

Cohort 2: South African Safe Passage Study

Study design and setting

This data comes from the feasibility phase of the childhood follow up of the Safe Passage longitudinal study (Dukes et al., 2014) which aims to explore the pre- and post-natal environmental risk factors for child development. 100 children aged 3-11 years (average age 7.6 years; 45 females) of mothers recruited at their antenatal appointment at Tygerberg Hospital (Cape Town) that took part in the antenatal study agreed to participate in the follow up. The study took place in Cape Town (South Africa; see Dukes et al., 2014 for details of the methods) and included an ante-natal timepoint and follow-up between 3-11 years of age. A specialised paediatrician assessed autism in this cohort via the Childhood Autism Rating Scale (CARS; Chlebowski et al., 2010; Moon et al., 2019; Moulton et al., 2019). The study was carried out upon approval of the local ethics review board at the study site. The SP study is currently ongoing, and the diagnostic outcome (autistic/non-autistic) has yet to be confirmed.

Questionnaires

We used variables related to prenatal and early postnatal risk (the number of cigarettes smoked per day and the total standard drinks per day during pregnancy; the Edinburgh Postnatal Depression Scale, Eberhard-Gran et al., 2001), and demographics (education, employment, income, having phone and services at home) that were collected from the mother antenatally or after birth (see Table 2). The Oxford-Liverpool Inventory of Feelings and Experiences (O-LIFE; Burch et al., 1998), Strength and Difficulties Questionnaire, Verbal Comprehension Index, Perceptual Reasoning Index and Childhood Autism Rating Scale were collected at the childhood time point. The Verbal Comprehension Index and Perceptual Reasoning Index were calculated from different combinations of tests (the Mullen Scales of Early Learning, Visual Reception, Receptive and Expressive Language T-scores, normalised, for children aged 4-6, Mullen, 1995, and the Wechsler Intelligence Scales for Children from age 6). The Childhood Autism Rating Scale (CARS-2; Schopler et al., 1980) - a clinician behaviour rating scale - was used to screen autistic symptoms, rated on a scale from normal

to severe, and yielding a composite score ranging from non-autistic to severely autistic. See Table 2 and Figure 2 for an illustration of the distribution of these variables.

Table 2: sample size, sex ratio and average age of Cohort 2, plus descriptive statistics of the continuous variables

Cohort 2 (SP)				
Variable	Antenatal/follow-up	Mean	Standard Deviation	Range
N		100		
N Females (M:F)	follow-up	47 (2.12:1)		
Age	follow-up	7.92	2.32	7.65
Strength and Difficulties Questionnaire Externalising	follow-up	8.52	4.02	15.00
Strength and Difficulties Questionnaire Internalising	follow-up	5.50	3.25	16.00
Childhood Autism Rating Scale	follow-up	16.17	2.22	15.00
Verbal Comprehension Index	follow-up	84.19	17.77	86.56
Percept	follow-	88.01	15.72	88.21

ual Reasoning Index	up			
Short Oxford-Liverpool Inventory of Feelings and Experiences (O-LIFE)	Antenatal	3.85	4.47	18.00
Maternal BMI during pregnancy	Antenatal	25.79	6.48	29.77
Income	Antenatal	717.50	424.75	1916.67
Edinburgh Postnatal Depression Scale	Postnatal	14.10	5.54	26.00
Cig/ Day (SD)	Antenatal	2.89	3.37	17.69
Drinks/ Pregnancy (SD)	Antenatal	9.52	20.42	131.17

[insert Figure 2]

Figure 2: Values and percentage distribution of the demographic variables of Cohort 2

Community involvement

This project involves secondary analysis of data collected 2014-2017 (LEAP) and in 2018 (SP) which did not include direct community consultation. The inception of the current analysis resulted from discussion between the first authors and the Autistic Representatives of AIMS-2-

TRIALS (i.e., compensated group of autistic people and parents who provide consultation to the AIMS-2-TRIALS research consortium).

Personal and Environmental Factors

For the analysis, we selected the available socio-economic and clinical variables (Table 3) in accordance with models formalising the socio-economic status as a stressor concurring with personal characteristics, parental and family resources in the determination of personal outcomes (Perry, 2004). Additionally, we include Age because of the different age ranges of the cohorts to control for it in the factor scores and the following regression analysis.

Table 3: Personal and environmental variables included in factor analysis

	LEAP	SP
Personal factors	Age (group) Verbal Comprehension Index Perceptual Reasoning Index Vineland Adaptive Behaviour Scale Psychotropic medication use	Age (group) Verbal Comprehension Index Perceptual Reasoning Index
Environmental factors	Parental Employment Status Parental Education (title achieved) Annual Household Income (Range <20k to >100k) Type of House Housing (social, rented, owned) Number of bedrooms Living Arrangement (institution/with family/with flatmates/partner/alone) Number of people economically dependent on parents (children + other adults) Household size (number of people in the household)	Maternal Employment Status Maternal Education (years) Annual Household Income (South African Rand) Type of House Having a phone (landline/cell) House with water House with toilet Parity (number of times a woman has given birth after 24 weeks of pregnancy) Marital Status Maternal Body Mass Index (BMI) during pregnancy

		Preterm birth Short Oxford-Liverpool Inventory of Feelings and Experiences (O-LIFE) Edinburgh Postnatal Depression Scale Cigarettes per Day Drinks per Day

Analysis

The same analyses have been applied separately to the two datasets. First, we established the optimal number of factors with a parallel analysis that compares the number of factors obtained with the data and random data of the same size as a control (Floyd & Widaman, 1995). Second, we estimated the factors loading with Minimal Residual Factor Analysis, with Minimal Oblique Rotation. Variable loadings are descriptive and represent the relative contribution of each variable to the factor; their sign relates to demographics contributing to high factor scores. All loading categorical variables possess intrinsic order, so they are interpreted as ordinal/discrete numerical in the factor analysis, e.g., positive loading of a categorical variable such as parental education means that higher factor scores reflect higher level of education achieved. Finally, we generated factor scores via regression. In case of missing data in one variable <75% of the total variable loadings, the value of that variable was imputed with the sample median to calculate the factor score, otherwise that factor score was dropped. Last, we used the newly generated factor scores as predictors of the Strengths and Difficulties Questionnaire Total Score with multiple linear regression, in interaction with autistic traits; we then used the Internalising and Externalising Subscales as dependent variables of multiple linear regression to examine which subdomain drove the effect. Numerical interaction effects between socio-economic factors and autistic traits are to be summed/subtracted (depending on their direction) from the intercept and the main effects of the socio-economic factors; in the text, we interpret net interaction effects where summation/subtraction has been highlighted to the reader.

Results

Factor Analysis

Cohort 1 (LEAP)

The Parallel Analysis detected 4 factors as ideal for the LEAP (Figure 3).

[insert Figure 3]

Figure 3: Scree plot; the N of factors at the intersection indicates the ideal number of factors.

The factor analysis showed acceptable reliability (RMSE=0.04, RMSEA=0.11, and TLI=0.71; Baldner & McGinley, 2014). The 4 factors received distinct loads from the demographic variables, of which we report here those with loading >/= 0.50 (see Table 4, and Figure 3 for complete list), and were labelled accordingly:

1. Person Characteristics: participants' adaptive and cognitive profile with positive loading from Vineland Adaptive Behaviour Scales, Perceptual Reasoning Index, Verbal Comprehension Index;
2. Family System: this factor relates to family size with positive loading from number of dependents, age;
3. Parental Resources: parents' background and wealth with positive loadings from parental education, occupation, household income;
4. Material Resources: environment the family can afford to live in, with positive loadings from housing, house type, number of bedrooms.

Table 4: Variable loadings representing (>0.50 are considered significant).

LEAP	Person Characteristics	Family System	Parental Resources	Material Resources
Child Age	-0.32	-0.60*	-0.03	0.16
Vineland Adaptive Behaviour Scales	0.67*	0.19	-0.06	0.01
Verbal Comprehens	0.92*	-0.05	0.02	0.01

ion Index				
Perceptual Reasoning Index	0.72*	-0.04	0.08	0.05
Psychotropic Medication	-0.11	-0.05	-0.03	-0.12
Maternal Education	0.06	0.00	0.70*	-0.05
Paternal Education	0.04	-0.05	0.65*	-0.01
Number of Dependents	-0.09	0.81*	0.04	0.05
Housing	0.19	-0.06	0.04	0.64*
House Type	-0.13	0.01	-0.02	0.58*
Living Arrangement	0.13	-0.37	-0.01	0.09
Paternal Occupation	0.01	-0.04	0.50*	0.10
Maternal Occupation	-0.1	0.08	0.63*	-0.04
Annual Income	0.02	0.05	0.43	0.39
Household Size	0.00	0.99*	-0.02	0.02
Bedrooms	-0.01	0.18	-0.02	0.54*

[insert Figure 4]

Figure 4: radar plot

The correlation between the factors was small, with the correlations > 0.2 between Child's Characteristics and Parental Resources (r = 0.28), and Parental Resources and Material Resources (0.36).

Cohort 2 (SP)

The Parallel Analysis detected 4 factors as ideal for the SP sample (Figure 2).

[insert Figure 5]

Figure 5: Scree plot; the N of factors at the intersection indicates the ideal number of factors.

The factor analysis showed an acceptable reliability (RMSE=0.05, RMSEA=0.05, and TLI=0.85). The 4 factors received distinct loads from the demographic variables, of which we report here those with loading >/= 0.50, and were labelled accordingly:

1. Person Characteristics: participants' adaptive and cognitive profile with positive loading from Vineland Adaptive Behaviour Scales, Perceptual Reasoning Index, Verbal Comprehension Index;
2. Family System: family size and maternal factors with positive loading from parity, pregnancy BMI, and negative loadings from participant age and marital status;
3. Parental Resources: mothers' background and wealth with positive loadings from education, occupation, and household income;
4. Material Resources: environment the family can afford to live in with positive loadings from house types, running water, and toilets.

Table 5: Variable loadings representing (>0.50 are considered significant).

SP	Person Characteristics	Family System	Parental Resources	Material Resources
Age	-0.78*	-0.03	0.11	-0.1
Verbal Comprehension Index	0.79*	-0.09	0.09	-0.07
Perceptual Reasoning Index	0.62*	0.1	0.13	-0.04
Short Oxford-Liverpool Inventory of Feelings and Experiences (O-LIFE)	-0.12	0.19	-0.03	-0.06
Marital	-0.13	-0.62*	-0.05	0.18

Status				
Employment Status	0.03	0.2	0.50*	-0.1
Education in Years	0.16	0.05	0.56*	0.21
Maternal Body Mass Index (BMI) during pregnancy	-0.15	0.66*	0.16	0.16
Annual Household Income	0.24	0.18	0.46	0.05
House Type	-0.02	0	0	0.82*
Having a phone	0.17	-0.16	0.36	0.02
House with Water	0.04	-0.08	0.04	0.86*
House with Toilet	-0.02	0.09	-0.03	0.82*
Edinburgh Postnatal Depression Scale	-0.21	-0.02	-0.22	-0.02
Parity	0.08	0.51*	-0.42	-0.05
Cigarettes/ Day	0.07	0.01	-0.35	-0.05
Drinks/Day	-0.22	-0.01	-0.03	-0.17
Preterm Birth	0.16	-0.03	-0.4	0.15

[insert Figure 6]

Figure 6: radar plot

The correlations between the factors were small, with the only correlation > 0.2 between Child's Characteristics and Parental Resources (r = 0.27).

Regression Analysis

Cohort 1 (LEAP)

Strength and Difficulties Questionnaire Total (Table 6A) was significantly lower in participants with higher scores on Family System (bigger family, older child ages), and higher in participants with high Autistic Quotient scores. Family System significantly and positively interacted with Autistic Quotient, indicating that Family System had less of a protective effect on participants showing lots of autistic traits on the Autistic Quotient.

Strength and Difficulties Questionnaire Internalising Score (Table 6B) was significantly lower with higher scores on the Family System (bigger family, older ages) factor, and higher in participants with high Autistic Quotient scores. The interaction between Family System and Autistic Quotient was significant, showing the same result as with the Strength and Difficulties Questionnaire Total score. Strength and Difficulties Questionnaire Externalising Score (Table 6C) was significantly higher in participants with high Autistic Quotient score, and its interaction with Family System was significant. *Table 6: Regression outputs of models of Strength and Difficulties Questionnaire Total (A) and subscales Internalising (B) and externalising (C). Significant effects are marked with **.

(A)

Strength and Difficulties Questionnaire Total	Coefficient	Standardised Coefficient	St. Error	T-value	P-value
(Intercept)	4.77	-	1.53	3.11	<0.001*
Person Characteristics	-2.47	-0.32	1.48	-1.67	0.10
Family System	-3.83	-0.55	1.32	-2.9	<0.001*
Parental Resources	0.38	0.04	1.63	0.23	0.82
Material Resources	0.13	0.01	1.74	0.08	0.94
Autistic Quotient	0.13	0.48	0.02	8.00	<0.001*
Person Characteristics * Autistic	0.01	<0.001	0.02	0.64	0.52

Quotient					
Family System * Autistic Quotient	0.05	0.01	0.01	3.27	<0.001*
Parental Resources * Autistic Quotient	-0.01	<0.001	0.02	-0.41	0.68
Material Resources * Autistic Quotient	-0.01	<0.001	0.02	-0.66	0.51

(B)

Strength and Difficulties Questionnaire Internalising Score	Coefficient	Standardised Coefficient	St. Error	T-value	P-value
(Intercept)	1.49	-	0.97	1.55	0.12
Person Characteristics	-1.16	-0.25	0.93	-1.24	0.22
Family System	-2.83	-0.67	0.83	-3.4	<0.001*
Parental Resources	0.05	0.01	1.03	0.04	0.97
Material Resources	0.97	0.16	1.10	0.88	0.38
Autistic Quotient	0.08	0.47	0.01	7.71	<0.001*
Person Characteristics * Autistic Quotient	0.01	<0.001	0.01	0.68	0.50
Family System * Autistic Quotient	0.03	0.01	0.01	2.97	<0.001*
Parental Resources * Autistic Quotient	-0.01	<0.001	0.01	-0.49	0.62
Material Resources * Autistic Quotient	-0.01	<0.001	0.01	-0.88	0.38

(C)

Strength and Difficulties Questionnaire Externalising Score	Coefficient	Standardised Coefficient	St. Error	T-value	P-value
(Intercept)	3.28	NA	0.99	3.32	<0.001*
Person Characteristics	-1.32	-0.31	0.95	-1.38	0.17
Family System	-1	-0.25	0.85	-1.17	0.24
Parental Resources	0.33	0.06	1.05	0.32	0.75
Material Resources	-0.84	-0.15	1.12	-0.75	0.46
Autistic Quotient	0.05	0.33	0.01	4.88	<0.001*
Person Characteristics * Autistic Quotient	<0.001	<0.001	0.01	0.34	0.74
Family System * Autistic Quotient	0.02	0.01	0.01	2.17	0.03*
Parental Resources * Autistic Quotient	<0.001	<0.001	0.01	-0.16	0.87
Material Resources * Autistic Quotient	<0.001	<0.001	0.01	-0.17	0.87

Cohort 2 (SP)

Strength and Difficulties Questionnaire Total (Table 7A) was significantly higher with greater scores on Family System (higher maternal BMI, higher parity and unmarried mother). Childhood Autism Rating Scale too was positively and significantly associated with the Strength and Difficulties Questionnaire Total. But the negative interaction between Family System and Childhood Autism Rating Scale meant that higher scores on both were associated with lower Strength and Difficulties Questionnaire.

Strength and Difficulties Questionnaire Internalising Score (Table 7B) was significantly higher with higher scores on the Family System (higher maternal BMI, higher parity and unmarried mother) factor. Childhood Autism Rating Scale also significantly increased Strength and Difficulties Questionnaire Total. But the significant negative interaction between Family system and Childhood Autism Rating Scale means that higher scores on Family System and Childhood Autism Rating Scale were associated with lower Strength and Difficulties Questionnaire Internalising scores.

Strength and Difficulties Questionnaire Externalising Score (Table 7C) did not significantly vary with any of the predictors.

Table 7: Regression outputs of models of Strength and Difficulties Questionnaire Total Score (A) and subscales Internalising (B) and externalising (C).

(A)

Strength and Difficulties Questionnaire Total	Coefficient	Standardised Coefficient	St. Error	T-value	P-value
(Intercept)	-11.32	-	8.67	-1.31	0.20
Person Characteristics	-7.41	-1.14	15.54	-0.48	0.63
Family System	26.65	3.94	11.34	2.35	0.02*
Parental Resources	-10.05	-1.37	11.8	-0.85	0.40
Material Resources	3.46	0.56	10.14	0.34	0.73
Childhood Autism Rating Scale	1.61	0.47	0.55	2.94	<0.001*
Person Characteristics * Childhood Autism Rating Scale	0.44	0.07	0.99	0.45	0.66
Family System * Childhood Autism Rating Scale	-1.65	-0.24	0.71	-2.32	0.02*
Parental Resources * Childhood	0.54	0.07	0.75	0.72	0.47

Autism Rating Scale					
Material Resources * Childhood Autism Rating Scale	-0.23	-0.04	0.64	-0.37	0.71

(B)

Strength and Difficulties Questionnaire Internalising Score	Coefficient	Standardised Coefficient	St. Error	T-value	P-value
(Intercept)	-8.04	NA	4.89	-1.65	0.10
Person Characteristics	7.11	1.93	8.76	0.81	0.42
Family System	13.87	3.61	6.39	2.17	0.03*
Parental Resources	-10.29	-2.47	6.65	-1.55	0.13
Material Resources	-4.61	-1.31	5.72	-0.81	0.42
Childhood Autism Rating Scale	0.85	0.44	0.31	2.76	0.01*
Person Characteristics * Childhood Autism Rating Scale	-0.49	-0.13	0.56	-0.87	0.39
Family System * Childhood Autism Rating Scale	-0.89	-0.23	0.4	-2.22	0.03*
Parental Resources * Childhood Autism Rating Scale	0.63	0.15	0.42	1.49	0.14
Material Resources * Childhood Autism Rating Scale	0.28	0.08	0.36	0.77	0.44

(C)

Strength and Difficulties Questionnaire Externalising Score	Coefficient	Standardised Coefficient	St. Error	T-value	P-value
(Intercept)	-3.29	-	6.33	-0.52	0.60
Person Characteristics	-14.52	-3.2	11.34	-1.28	0.20
Family System	12.78	2.7	8.27	1.54	0.13
Parental Resources	0.24	0.05	8.61	0.03	0.98
Material Resources	8.07	1.86	7.40	1.09	0.28
Childhood Autism Rating Scale	0.76	0.32	0.40	1.9	0.06
Person Characteristics * Childhood Autism Rating Scale	0.93	0.2	0.72	1.28	0.20
Family System * Childhood Autism Rating Scale	-0.76	-0.16	0.52	-1.46	0.15
Parental Resources * Childhood Autism Rating Scale	-0.09	-0.02	0.55	-0.16	0.87
Material Resources * Childhood Autism Rating Scale	-0.51	-0.12	0.46	-1.10	0.27

Discussion

The structure of environment and personal factors

In this paper we examined individual and environmental predictors of internalising and externalising symptoms, and their interaction with autistic traits. We found 4 similar factors across

two distinct cohorts from Europe and South Africa, one that included participants' cognitive and adaptive function ("Person Characteristics"), and three relating to the participants' living environment (Family System, Parental Resources, Material Resources). As the factor analysis was conducted separately for each cohort, the included variables and the internal factor structure (reflected on the variables loadings) differed between cohorts. Nonetheless, despite differences in measured variables, setting and demographics, the resulting factors captured similar concepts (for instance, Family System included family size and parity in Cohort 1 and 2 respectively, both broadly related to household size).

Effect of environment and personal factors on internalising and externalising symptoms

When predicting internalising and externalising symptoms, we found similar relationships across settings and populations. In both cohorts, Family System was a significant predictor of internalising and externalising symptoms, with an interaction with autistic traits. Family system consisted of the number of dependents and household in LEAP, and parity, maternal pregnancy BMI and maternal mental health in SP. Other environmental and personal factors (Person Characteristics, Parental Resources, and Material Resources) were not found to be significant predictors in either cohort.

Cohort 1 (LEAP)

In the large European cohort, LEAP, Family System comprised participants' age, number of dependents, and household members. Our results suggested that children who are younger, and with a larger family are less likely to report internalising and externalising symptoms. This may be that larger families provide additional support to a child and protect against these symptoms. Whilst more granular data (e.g., information on whether this includes siblings, grandparents, aunts and uncles etc) would aid in the interpretation of these results, this finding has to some extent been supported in the literature, where family and social support has been shown to be protective of child and infant cognition (Juvrud et al., 2021; Sonuga-Barke & Mistry, 2000; Taylor et al., 2015). Also, for example, large population-based longitudinal studies in Australia found that a small family was a significant

predictor of internalising behaviours in preschool children (Bayer et al., 2008, 2012; Symeonides et al., 2021), which is in keeping with our results.

Cohort 2 (SP)

In SP, we found a relation with the same domain but opposite direction, where higher scores of Family System related to more symptoms, particularly internalising symptoms. A high score for Family System corresponded to married/partnered families, with high pregnancy BMI and parity - variables that have been reported to positively associate as women gain weight with successive pregnancies (Iversen et al., 2018). This might be reflective of a larger family and greater division of resources; therefore, a predictor of internalising behaviours in children in South Africa might include having a large family, differently from Western settings as outlined in the previous paragraph and as evidenced from other low/middle income settings (Geetha et al., 2019; He et al., 2018). This cohort difference may also be due to the different variables within Family System, but nonetheless may measure coherent processes across cohorts (e.g., household members and married parents may be reflecting support, while number of dependents and parity may be reflecting siblings).

Effect of autistic traits

In both cohorts, the interaction between autistic traits and Strength and Difficulties Questionnaire scores suggests that those with greater autism traits are at higher risk of internalising and externalising symptoms, keeping with prior evidence (Hoekstra et al., 2007). In the SP cohort this was only significant for internalising symptoms, however due to smaller sample size a lack of significance may be due to lack of power.

Across both cohorts, autistic traits were associated with a reduction in the effect of family systems. In LEAP, the family system had less positive impact on internalising and externalising symptoms in individuals with higher autism traits: in this context, Family System may be reflective of a more hectic, busy and potentially noisy family and which provides an environment for an autistic child that is more difficult to control. This may be especially difficult to manage for children with hyper-sensitivities (e.g., to noise) that link to internalising symptoms in autistic children (Rossow et

al., 2021). In keeping with the limited evidence available in this area, these findings suggest that whilst a larger family may be protective of a child experiencing internalising and externalising symptoms, this effect is diminished for participants with high autism traits. An effect in the same domain but opposite direction was found in SP, where having high Childhood Autism Rating Scale scores decreased the precipitating effect of Family Systems on internalising symptoms.

Before, it has been highlighted that assumed differing levels of autistic traits in autistic populations (Ronald et al., 2006) affect mental health (Simonoff et al., 2013); we have actually demonstrated that this is the case both in our diagnosed and undiagnosed sample. Additionally, our findings suggest that context influences mental health outcomes, for instance household members providing social support in a high-income setting can protect from poorer mental health outcomes, but a larger family subdividing resources in an upper-middle income setting can have the opposite effect. Our results further show that context and autistic traits interact to influence mental health, and this could be explained by differences in infrastructural support at the societal level that modifies the relative importance of household members providing support to the individual with high autistic traits.

Limitations

The Strength and Difficulties Questionnaire is parent-reported measurements of symptoms, which could be influenced by masking (Cook et al., 2022). Furthermore, parental educational level, the child's gender and household income moderate the mismatch between parent and self-reported symptoms (Van Roy et al., 2010). Therefore, the difference between child self-/parental-report of Strength and Difficulties Questionnaire should be taken into account in future research, to establish whether autistic traits truly exert a protective effect. With regard to the different variables used across cohorts, the factor Family System describes the family numerosity but in structurally different ways, such as parity (recorded in SP) vs household members (recorded in LEAP), that may also bring a different degree of socio-economic pressure on the parents (e.g., not all children included in the parity measure may live at home) and limit generalisability.

A few additional limitations stem from using two separate cohorts, with different settings, sizes, recruitment (clinical autistic vs population-based cohort), ages (child to adult vs. young to mid-

childhood), design of data (concurrent vs longitudinal) and risk and outcome measures not being collected at the same time, a limitation that specifically affects prenatal factors in SP. Future studies need to use harmonised samples and longitudinal sampling for better distinction between family/socio-demographic variables, autism vs autistic traits, age effects, and of factor structures that are sensitive to both local and general stressors.

A final limitation is that the two cohorts used different measures of autistic traits – the Autistic Quotient and the Childhood Autism Rating Scale. Whilst both measurements have been validated and widely used, they measure slightly different constructs of autism traits, with Childhood Autism Rating Scale often used to assess symptoms severity (Schopler et al, 1988), and Autistic Quotient measuring the degree to which an individual shows autistic traits (Baron-Cohen et al., 2001). However, a higher score on either scale represents increased autistic traits (Thabtah & Peebles, 2019).

Conclusion

We examined individual and environmental predictors - aggregated with exploratory factor analysis - of internalising and externalising symptoms, and their interaction with autistic traits. Despite the differences, we identified 4 factor structures, and one factor, Family System, associated with internalisation and externalisation scores, with different directions between cohorts. This observation supports the idea that variability across settings can improve validity of multifactorial socio-economic measures. Across both cohorts, we found that autistic traits were associated with internalising and externalising symptoms and a reduction in the effect of Family Systems. This suggests that factors around social resources in both the family and broader society may be relevant to mental health conditions in people on the autism spectrum. The opposite direction of effects may represent two sides of a complementary picture of the factors' impact on mental health.

In conclusion, this attempt to jointly evaluate cohorts from different settings tested the use of autistic traits as a moderator and of differing environmental variables (by design as well as by accident), that require additional efforts for interpretation but capture meaningful, specific

relationships between environment and symptoms, with enhanced validity across settings (Wuermli et al., 2015).

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Conflicts of Interest (details omitted for double-anonymized peer review)

JT has acted as a paid consultant and is a current employee of F. Hoffmann-La Roche AG. TC has acted as a paid consultant of F. Hoffmann-La Roche Ltd and Servier and receives royalties for the publication of textbooks for Guilford Press and Sage Publications. JB has been in the past 3 years a consultant to/member of advisory boards of/and/or speaker for Janssen Cilag BV, Eli Lilly, Lundbeck, Shire, Roche, Novartis, Medice, and Servier. SB receives royalties for the German and Swedish KONTAKT manuals and adaptations of the ADI-R, ADOS, and SRS from Hogrefe Publishers, and has in the last 3 years acted as an author, consultant, or lecturer for Medice and Roche. TB has served in an advisory or consultancy role for eye level, Infectopharm, Lundbeck, Medice, Neurim Pharmaceuticals, Oberberg GmbH, Roche, and Takeda. He received conference support or speaker's fee by Janssen, Medice and Takeda. He received royalities from Hogrefe, Kohlhammer, CIP Medien, Oxford University Press; the present work is unrelated to these relationships. ASJC has acted as a paid consultant for F.Hoffman-La Roche and Servier and has been actively involved in clinical trials managed by both companies. All other authors report no biomedical financial interests or potential conflicts of interest.