



# Early childhood and early adolescent predictors of internalising symptoms in adolescents: findings from a longitudinal study in a high-risk South African environment

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## Abstract

**Purpose** This study investigates predictors of internalising symptoms among adolescents aged 16 to 19 years in a high-risk context in South Africa. Specifically, it explores early childhood (antenatal to 18 months postpartum), and early adolescent (13 to 14 years) predictors of internalising symptoms measured during later adolescence (16–19 years), aiming to identify key factors influencing mental health outcomes in this vulnerable population.

**Methods** Utilising a unique 18-year longitudinal dataset, we included a total of 314 adolescent participants from South Africa in the analysis and employed an adaptive elastic net regularised regression to analyse the effects of 18 predictors from early childhood and early adolescence on internalising symptoms at ages 16 to 19 years. The broadband scale for “internalising” from the Youth Self Report (ages 11–18) was used as the outcome measure. Data collected at five time points across three phases of the longitudinal study were included in the analysis.

**Results** Key predictors of internalising symptoms were female sex ( $\beta=-4.30$ ; 95% CI [-4.42;4.19]). Early childhood predictors with significant associations were maternal depression ( $\beta=1.70$ ; 95% CI [1.56;1.84]) and caregiver employment ( $\beta=-0.37$ ; 95% CI [-0.46;-0.29]). In early adolescence, significant predictors included informal house type ( $\beta=0.82$ ; 95% CI [0.71;0.93]), caregiver alcohol use ( $\beta=0.74$ ; 95% CI [0.67;0.81]), exposure to violence ( $\beta=0.73$ ; 95% CI [0.67;0.78]), friend support ( $\beta=-0.61$ ; 95% CI [-0.67;-0.55]), food insecurity ( $\beta=0.51$ ; 95% CI [0.46;0.56]), family support ( $\beta=-0.33$ ; 95% CI [-0.37;-0.29]), and self-esteem ( $\beta=-0.33$ ; 95% CI [-0.37;-0.29]).

**Conclusion** This study identifies key predictors of internalising symptoms in adolescents from high-risk context, focusing on caregiver variables and social connections. Maternal / Primary caregiver depression and caregiver unemployment in early childhood have lasting effects, highlighting the need for early intervention. In early adolescence, factors such as social environment and caregiver stability are crucial. These insights can inform targeted interventions and policies to support adolescent mental health in high-risk contexts.

**Keywords** Adolescents; internalising symptoms · High-Risk content · Longitudinal study

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## Background

Adolescence is a crucial developmental period characterised by significant physical, cognitive, and emotional changes [1], and a time where mental health conditions often emerge [2]. Poverty has been suggested to be a critical determinant of poor mental health outcomes among the adolescent population [3–9]. In high-adversity contexts, adolescents face multiple associated secondary challenges (e.g., exposure to community violence, poor family functioning) and often have limited access to resources that could help them cope effectively (e.g., mental health services) [10–12].

A critical lack of evidence on prevalence rates of mental health conditions among adolescents in low- and middle-income countries (LMIC) exists, especially in sub-Saharan African (SSA) countries, and particularly for adolescents living in adverse contexts such as informal settlements, where data coverage is almost non-existent [13]. Despite the lack of availability of epidemiological data on internalising symptoms in SSA, it is estimated that between 15% and 41% of adolescents in South Africa experiences symptoms of mental health conditions [14–16].

This study focuses on adolescents in South Africa as it is a country with high rates of poverty, unemployment, and community violence, which are key risk factors for internalising symptoms in adolescents. The prevalence of mental health symptoms in this population is high, but there is a lack of research on the specific predictors of poor mental health in these high-risk settings.

Generally, a range of risk factors have been established for adolescent internalising symptoms [17–22]. However, high poverty, a risk factor almost universally present in adverse LMIC contexts, has been suggested to influence the mental health of adolescents directly, as well as through various indirect pathways that are likely not captured by HIC studies. As a result, adolescents living in poverty in LMICs often experience challenging conditions directly linked to such conditions, such as food insecurity or lack of stable housing [23]. Also, they may also face secondary consequences, including chronic stress, poor family functioning, family instability, and/or parental substance use and other mental health conditions [24–26]. Furthermore, they are faced with broader poverty-associated challenges outside the home environment such as limited access to education and healthcare [27, 28], as well as exposure to high levels of community violence [29]. It also has been suggested that adolescents facing stressors related to living in high poverty settings may experience feelings of hopelessness, helplessness, and social isolation [30]. Overall, all these risk factors may interact and compound each other and as a result, living in impoverished conditions has been linked to increased risks of internalising symptoms and mental health conditions

in adolescents [7, 13, 17]. However, there is a need to better understand which of the risk factors described above may be the key drivers of such associations. This understanding is crucial to inform timely and targeted interventions that can effectively address the mental health challenges faced by adolescents living in high risk contexts in LMICs, and to inform the design of preventative intervention rather than interventions after the problems arise. Variable-selection approaches, based on current available literature, may be particularly suitable for such an undertaking, as they identify the most important predictors across a set of correlated variables, as in the current case.

Of note, while recent exposures (i.e., during adolescence) often show larger predictive effects, early childhood has been proposed to be a key developmental phase during which a child develops critical cognitive abilities, emotional regulation skills, and attachment through interactions with their parents or caregivers [31, 32]. Early childhood development has been shown to be affected by poverty and associated risk factors [31], which can have lasting negative effects throughout the life course [31, 33], including on mental health [34]. To design effective targeted interventions, it is thus of interest to investigate how predictors during early childhood influence the development of internalising symptoms in adolescence, and whether they have unique predictive effects above and beyond factors assessed later in life (in this case for adolescence).

The selection of early adolescent predictors was guided by existing literature on risk and protective factors for adolescent mental health in similar contexts. Variables such as house type (formal vs. informal housing), caregiver depression, caregiver alcohol use, exposure to violence, and food insecurity were chosen as they are well-established socioeconomic and environmental risk factors prevalent in high-risk, low-income setting. In addition, protective factors, including family support and friend/peer support were included to capture the influence of social relationships on mental health outcomes. Finally, self-esteem was included as an important psychological variable known to be a strong protective factor against the development of internalising symptoms in adolescents.

In summary, the current study aims to apply an elastic net variable-selection approach, in order to identify key early childhood and early adolescent predictors of internalising symptoms amongst 16 to 19 year-old adolescents in a high-risk LMIC context. It utilises data from a longitudinal study conducted in a South African informal settlement and includes data on early childhood predictors (antenatally to 18 month postpartum) and early adolescent predictors (13 to 14 years).

## Methods

### Setting

This longitudinal study took place in Khayelitsha, which is the fastest growing and largest township in the Western Cape, South Africa [35]. The estimated population of Khayelitsha is between 400 000 and 750 000, of which 99% are of Black African origin [36–38]. The township has the largest concentration of informal settlements in Cape Town and consists of a combination of formal (i.e., brick housing) and informal areas (i.e., shacks or temporary housing) [36, 37]. Half of Khayelitsha’s population falls within the poorest income quintile for Cape Town and it has an unemployment rate of between 38 and 74% [39, 40]. Khayelitsha also has the highest prevalence rate of HIV infections in the Western Cape [35], and the area is characterised by significantly high levels of crime and lack of consistent and effective service delivery and police services [41].

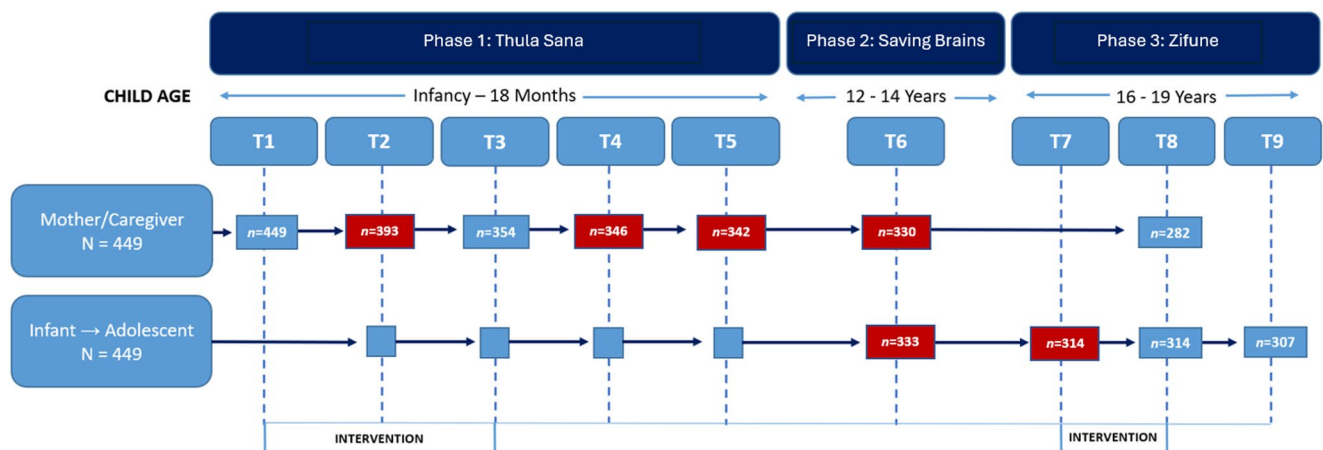
### Sample and procedures

Over a period of almost two decades, participants in this study were involved in a research project consisting of three phases. During Phase 1, conducted from 1999 to 2003, pregnant women in their third trimester were recruited to participate in a randomized controlled trial called “Thula Sana,” which aimed to improve maternal sensitivity and responsiveness [42]. During Phase 1, 449 pregnant women were enrolled into the study and assessed across five time-points from the antenatal period to 18 months post-partum. These five time-points were: antenatally ( $n = 449$ ); 2 months follow-up ( $n = 395$ –89%); 6 months follow-up ( $n = 354$ –79%); 12 months follow-up ( $n = 346$ –77%); and 18 months follow-up ( $n = 342$ –76%). Mothers randomised to

the intervention group received the Thula Sana intervention from the third trimester up until their infants were 6 months old. Mothers randomised to the control group received treatment as usual, which were government-delivered antenatal and maternity services. A significant beneficial effect on the mother-infant relationship was observed [42].

Phase 2 of the study, conducted between 2012 and 2014, was part of the “Saving Brains” initiative. A total of 333 (74%) children, between the ages of 13–14 years, along with their primary caregiver ( $n = 330$ ), were re-enrolled into the study to investigate the potential long-term beneficial effects of the Thula Sana intervention. Children were assessed on socio-emotional and cognitive functioning. No significant long-term impact on child development was observed. However, a positive effect on caregiver depression symptoms were observed [43]. Most recently, in 2018, during Phase 3 of the study, the children, now adolescents between the ages of 16 and 19 years, were re-enrolled and re-randomised into a new intervention trial called “Zifune”. Zifune aimed to evaluate the effect of a second-wave intervention to prevent violence amongst adolescents. During this phase of the study, adolescents were assessed during baseline ( $n = 314$ ); post-intervention follow-up ( $n = 314$ ); and 3-month follow-up ( $n = 307$ ); and their primary caregivers ( $n = 282$ ) at one time-point. Primary outcome data on internalising symptoms were collected during the Phase 3 baseline assessment. Exposure to the Thula Sana intervention (delivered during Phase 1) were controlled for. Figure 1 provide an overview of the longitudinal study.

To assess early childhood predictors of internalising symptoms amongst adolescents, data collected during three-time points (2-month follow-up, 12-month follow-up, and 18-month follow-up) during Phase 1 of the study were used. To assess early adolescent predictors, data collected during Phase 2 of the study, from adolescents and their caregivers, were used.



**Fig. 1** Longitudinal study time-points. Time-points included in this study are coloured in red. T1 (Antenatal); T2 (2 months follow-up); T3 (6 months follow-up); T4 (12 months follow-up); T5 (18 months follow-up); T6 (12–14 years follow-up); T7–T9 (16–19 years follow-up)

Ethical approval granted across the three phases of the project are as following: Phase 1 (University of Reading [ref: 99/20] and the University of Cape Town [ref: 180/97]); Phase 2 (Health Research Ethics Committee at Stellenbosch University [S12/04/113]); and Phase 3 (Health Research Ethics Committee at Stellenbosch University [N17/10/094]).

## Measures

### Sociodemographic factors

The following sociodemographic factors were considered in the analysis (measured both, at 12 months of age and 13 years): child sex (sex assigned at birth), housing type (formal housing vs. informal housing); number of household members, caregiver employment status (any employment versus no employment), and household monthly income (only available for Phase 2 of the study).

### Early childhood factors

#### Infant attachment style

The infants' attachment style was assessed at 18 months using the Strange Situation procedure developed by Ainsworth and colleagues [44]. This standardised assessment procedure included having the infant filmed through a one-way mirror, in an unfamiliar playroom, over a period of 21 min. During this period the infant underwent standardised episodes of separation and reunion with the mother in the presence of a stranger. Video recordings were then independently rated by a blinded reviewer to assess infants as securely or insecurely attached [42]. To establish inter-rater reliability, a subset of the videotapes was scored by a second trained rater that was also blinded to treatment conditions to confirm inter-rater agreement ( $k = 0.96$ ) [42].

#### Maternal sensitivity

To assess the quality of mother-child interaction, two episodes of structured play situations were recorded at 12 months of child age. During each of these three-minute episodes, mothers were asked to play with their infant by using novel toys (a form board and stacking rings) [42]. A rater, blinded to the treatment group, then scored the behaviour of the mother from the videotapes [42]. To establish inter-rater reliability, a subset of the videotapes was scored by a trained rater that was also blinded to treatment conditions. An established measure to rate sensitivity on a five point

scale was used [45, 46]. Sensitivity (comprising maternal expression of warmth, acceptance, and positive statements) was rated on a 5-point Likert-scale and summed across both tasks. Inter-rater reliability was established across 20 videotapes ( $k = 0.91$ ).

### Maternal depression

Maternal depression was assessed at 2 months post-partum by a trained isiXhosa speaking researcher through using the major depression section of the clinical interview for Diagnostic and Statistical Manual of Mental Disorders, fourth edition (DSM-IV) [47]. Following standard translation principles, the interview was translated and then back translated to isiXhosa [48]. Recorded interviews and interviewer notes were then reviewed and assessed by the interviewer and a clinical psychologist, both blinded to treatment group [42]. A joint decision was then made regarding the presence of each of the relevant symptoms, which formed the basis for determining the presence or absence of a DSM-IV major depressive disorder [42, 47].

### Early adolescent factors

#### Food insecurity

Food insecurity was assessed through the 9-item Household Food Insecurity Access Scale (HFIAS) administered to adolescents [49]. The HFIAS uses a recall period of four weeks (30 days) to capture perceptions of food security, including anxiety about food supply, perceptions of the variety and quality of diet and insufficient food availability. The total score range for the HFIAS is 0–27, with higher scores indicating higher levels of food insecurity. The HFIAS has previously been used in studies assessing food insecurity in South Africa [50–52]. The HFIAS has been validated in a SSA country, showing good internal consistency ( $\alpha = 0.90$ ) [53].

#### Family support

Adolescent perceived family support was assessed through the Multidimensional Scale of Perceived Social Support (MSPSS) scale [54]. The MSPSS is a 12-item scale and consists of three subscales assessing different sources of social support. The family support subscale consists of four items capturing perceived social support from family. The total score ranged from 4 to 12, with higher scores indicating higher levels of family support. The psychometric properties of the MSPSS ( $\alpha = 0.86$ ) have been demonstrated in a South African adolescent sample [55].

## Friend support

Friend support as perceived by the adolescent was assessed through the MSPSS [54]. The friend support subscale of the MSPSS consists of 4 items and follows the same procedure mentioned above (under ‘family support’).

## Self-esteem

Adolescents’ self-esteem was assessed through the 42-item Self-esteem Questionnaire (SEQ) [56]. Participants rated their agreement with items on six dimensions of self-esteem: peer relations, family, school, sport/athletics, body image, and global feelings of self-worth. The total score range is 42–168, with higher scores indicate higher levels of self-esteem. The SEQ has been previously validated in a South African adolescent population with adequate reliability for the majority of the subscales ( $\alpha$  between 0.75 and 0.85 except for sport/athletics) [57].

## Exposure to violence

Violence exposure was rated by the adolescents through the Child Exposure to Community Violence (CECV) [58]. A shortened version (27-items) of the CECV adapted for the South African population was used, which captures the frequency of both direct and indirect exposure to domestic and neighbourhood violence common in this context [59]. The total score ranges from 0 to 52, with higher score indicating higher levels of violence exposure. The CECV shows good internal consistency (current sample  $\alpha = 0.83$ ) and is robustly associated with adolescent PTSS [60].

## Caregiver alcohol use

Caregiver alcohol use was assessed through questions asking the caregiver about the frequency of their alcohol consumption over the past month. Those caregivers that indicated that in the past month have consumed three or more drinks in a single day, were then administered the TWEAK. The TWEAK test, an acronym for Tolerance, Worried, Eye-opener, Amnesia, and Kut-down (Cut down), is a short 5-item screener for harmful alcohol use [61]. The psychometric properties of the TWEAK have not been assessed in a South African population. However, the TWEAK has been previously used to assessed alcohol consumption in South African studies [62, 63].

## Caregiver stress

The Parental Stress Index Short Form (PSI-SF) was used to assess caregiver stress. The PSI-SF comprises of three

subscales capturing different parent-child problem areas: (1) parental distress; (2) parent-child dysfunctional interactions; (3) difficult child. Total scores range from 36 to 180, with lower scores indicating higher levels of caregiver stress. The PSI-SF has previously been found to have good internal consistency for the parental distress subscale ( $\alpha = 0.75$ ), the parent-child dysfunctional interactions subscale ( $\alpha = 0.85$ ), and the difficult child subscale ( $\alpha = 0.82$ ) [64].

## Caregiver depression symptoms

Caregiver depression symptoms were measured through the Patient Health Questionnaire (PHQ-9), which is a brief screening tool for depression [65]. Caregivers were asked to rate how often, over the past two weeks, they had been bothered by a range of symptoms of depression. Items are scored on a scale of 0–3 (0 = not at all; 1 = several days; 2 = more than half the days; 3 = nearly every day). The PHQ-9 has been extensively used and validated in several South African studies [66–68].

## Statistical analysis

All analyses were conducted in R version 4.3.0. In a first step, missing data patterns (for a summary, see supplementary file 1) resulting from participants dropping in and out of the study throughout their lifetime were addressed using the Multiple Imputation by Chained Equations (mice) algorithm, as implemented in the R package mice [69]. The algorithm iteratively imputes missing values by building predictive models for each incomplete variable using all other available variables in the dataset.

We then used the *miselect* package [70] to conduct an adaptive elastic net regularised regression to examine the effects of 18 early childhood and adolescence predictors on internalising symptoms at age 16 to 19 years. The elastic net is a regularisation technique that combines both the L1 (Lasso) and L2 (Ridge) penalties to perform variable selection amongst multiple correlated variables, with the aim of avoiding overfitting and controlling model complexity [71]. The adaptive elastic net approach extends the traditional elastic net by adapting the regularisation parameters for each predictor to achieve better prediction accuracy [72]. We used a gaussian link function and a stacked approach to combine estimates across the imputed datasets. For selecting tuning parameters, we performed a 5-fold cross-validation and selected the models with the lowest mean squared error (MSE). We also derived an approximate index of R-squared based on the MSE ( $R\text{-squared} = 1 - (\text{MSE}/\text{Var}(Y))$ ).

In order to account for the uncertainty associated with parameter estimation using the elastic net, we applied bootstrapping to the entire estimation procedure. We created 200

**Table 1** Sociodemographic characteristics of adolescents

Sociodemographic characteristics	<i>N</i>	Percentage	Mean	SD
Adolescent age (years)	314		17.2	0.6
RCT (Thula Sana intervention)	157	50%		
Adolescent sex				
Male	148	47%		
Female	166	53%		
House type				
Formal housing	236	75%		
Informal housing	78	25%		
Living circumstances				
Running water at home	258	82%		
Flush toilet in home/on premises	227	72%		
Electricity at home	306	97%		
Biological mother is primary caregiver	264	84%		
Household member count			4.9	1.9
Household food insecurity <sup>A</sup>			7.2	5.7
Household monthly income <sup>B</sup>				
R0 - R499	11	4%		
R500 - R1000	20	6%		
R1001 - R2000	49	16%		
R2001 - R5000	115	37%		
R5001 - R8000	42	13%		
> R8000	41	13%		
Data not available	36	11%		
Education				
Currently enrolled	262	83.5%		
Correct grade for age	128	49.0%		
Finished school	20	6.5%		
Left school	32	10.0%		
Repeated grade	186	59.0%		

<sup>A</sup> Score range from 0–27; Higher scores indicate higher levels of food insecurity; <sup>B</sup> Data not available for full sample

samples with replacement, and for each sample performed 20 multiple imputations. Stacked estimates for predictors, associated confidence intervals and the MSE/R-squared metric were pooled across bootstrapped datasets.

## Results

### Sociodemographic characteristics

The sociodemographic characteristics of the adolescent sample, collected during Phase 3 of the longitudinal study, are provided in Table 1. A total of 314 adolescent participants were included in the analysis. The mean age of adolescents was 17.20 years (SD=0.64), with 53% being female. A total of 157 (50%) of adolescents had participated in the Thula Sana intervention as infants along with their mothers. A total of 25% of adolescents lived in informal housing. More than half of the population (59%) reported having

**Table 2** Predictors and outcomes

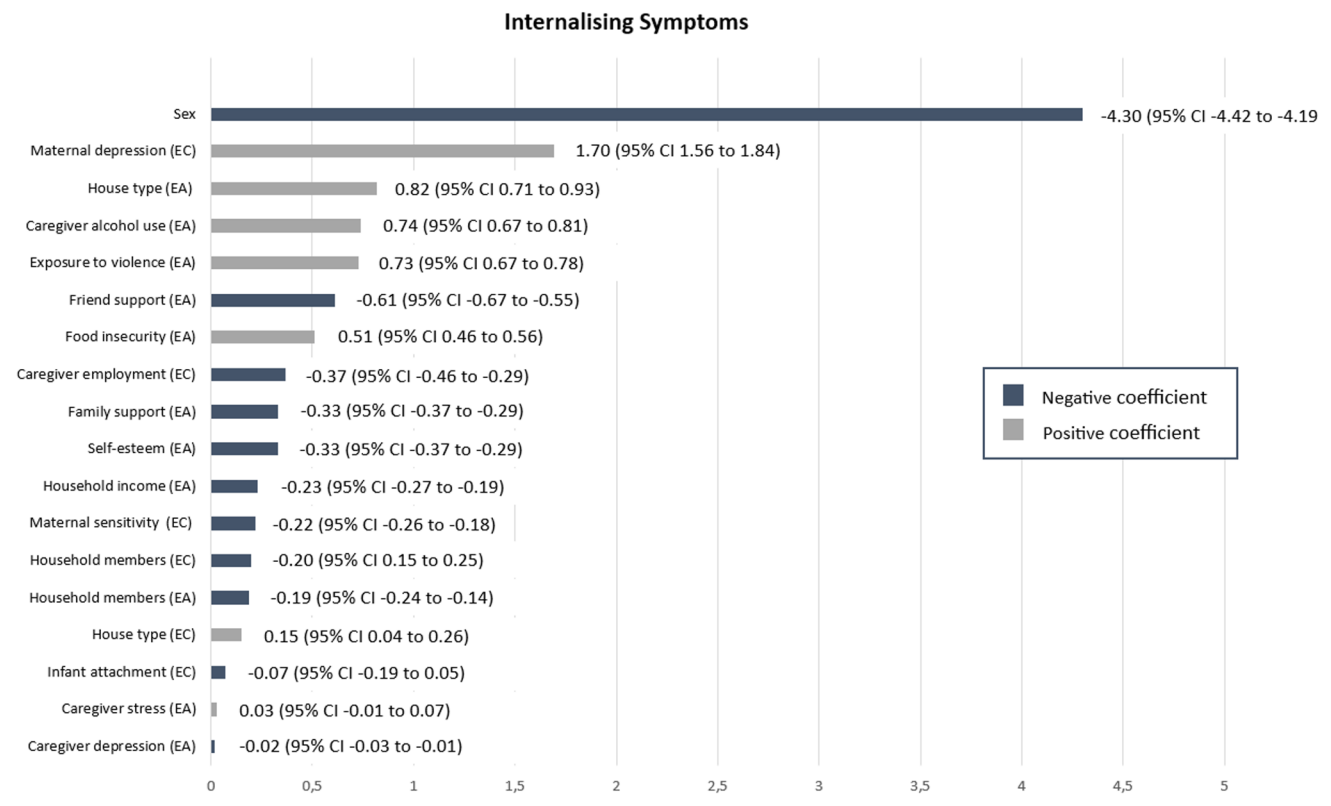
	Range	<i>N</i>	Percentage	Mean	SD
Early childhood predictors					
House type <sup>A</sup>					
Formal housing		59	21.0%		
Informal housing		227	79.0%		
Household member count <sup>A</sup>				4.7	1.8
Caregiver employment <sup>A</sup>					
Employed/Self-employed		57	20.0%		
Unemployed		229	80.0%		
Infant attachment <sup>C</sup>					
Secure attached		167	66.0%		
Insecure attached		85	34.0%		
Maternal sensitivity <sup>B</sup>	2–10			5.6	1.8
Maternal depression <sup>A</sup>					
Depressed		71	25.0%		
Not depressed		217	75.0%		
Early adolescent predictors <sup>D</sup>					
House type					
Formal housing		162	56.0%		
Informal housing		127	44.0%		
Household member count				3.7	1.9
Household monthly income					
R0 – R499		4	1%		
R500 – R1000		36	13%		
R1001 - R2000		72	25%		
R2001 – R5000		120	41%		
R5001 – R8000		37	13%		
> R8000		19	7%		
Household food insecurity	0–27			9.91	5.9
Family support	4–12			11.6	0.9
Friend support	4–12			8.9	2.4
Self-esteem	42–168			131.7	11.8
Exposure to violence	0–52			6.9	5.4
Caregiver alcohol use	0–10			1.1	2.2
Caregiver stress	36–180			123.4	19.9
Outcomes <sup>E</sup>					
Internalising symptoms	0–62			18.32	8.75
Total Score					

<sup>A</sup> Assessed at 2-month follow-up (Phase 1); <sup>B</sup> Assessed at 12-month follow-up (Phase 1); <sup>C</sup> Assessed at 18-month follow-up; <sup>D</sup> Assessed during Phase 2; <sup>E</sup> Assessed during Phase 3;

repeated one or more school grades, and 10% reported leaving school prior to completion.

### Early childhood and early adolescent predictors

Table 2 provides an overview of early childhood and early adolescent scores for each risk factor prior to multiple imputation. It highlights relatively high rates of poverty, with 79% of children living in informal housing at 2 months postpartum and 44% in adolescence, with high rates of maternal unemployment and 93% of household having



**Fig. 2** Elastic net results for internalising symptoms

a monthly income of  $\leq 8000$  ZAR at child aged 13 years. Table 2 shows the mean internalising symptoms score for the adolescent sample during Phase 3, which was 18.22 (SD=8.75; range: 0–62). See Supplementary file 2 for the Person correlation coefficients between predictors at early childhood (EC) and early adolescence (EA).

### Elastic net results

Figure 2 reports on the elastic net results for internalising symptoms, ranked by their coefficient size. The approximation of the R<sup>2</sup> value that we calculated based on the MSE indicated that 22% of the variance was explained on average across the bootstrapped datasets (hyperparameters:  $\alpha=0.85$ ,  $\lambda=0.03$ , RMSE=59.53).

The top 10 factors associated with higher levels of internalising symptoms were female sex ( $\beta = -4.30$ ; 95% CI [-4.42; -4.19]), higher levels of maternal depression during early childhood ( $\beta=1.70$ ; 95% CI [1.56; 1.84]), living in a formal house during early adolescence ( $\beta=0.82$ ; 95% CI [0.71; 0.93]), higher levels of caregiver alcohol use during early adolescence ( $\beta=0.74$ ; 95% CI [0.67; 0.81]), exposure to higher levels of family and community violence during early adolescence ( $\beta=0.73$ ; 95% CI [0.67; 0.78]), lower levels of friend support during early adolescence ( $\beta = -0.61$ ;

95% CI [-0.67; -0.55]), higher levels of food insecurity during early adolescence ( $\beta=0.51$ ; 95% CI [0.46; 0.56]), lack of caregiver employment during early childhood ( $\beta = -0.37$ ; 95% CI [-0.46; -0.29]), lower levels of family support during early adolescence ( $\beta = -0.33$ ; 95% CI [-0.37; -0.29]), and lower levels of self-esteem during early adolescence ( $\beta = -0.33$ ; 95% CI [-0.37; -0.29]).

### Discussion

This study aimed to identify the early childhood and early adolescent predictors of internalising symptoms amongst older adolescents (16 to 19 years old) living in a high-risk LMIC context characterised by poverty and associated secondary risks. Utilising data collected as part of a longitudinal study, with 18 years of follow up, we found that two variables from early childhood (maternal depression and caregiver employment) and seven during early adolescent (house type, caregiver alcohol use, exposure to violence, friend support, food insecurity, family support, and self-esteem) were amongst the strongest predictors of internalising symptoms.

Amongst all predictors that were assessed, female sex emerged as a key predictor of internalising symptoms. This

finding was not surprising, as multiple previous studies have found that internalising symptoms are more common amongst females than males during adolescence [73–76]. While biological factors, such as hormonal changes during puberty, play a role, their effect is often compounded by gendered socialisation and environmental factors that often disproportionately affects girls in high-risk settings like those in South Africa [76–78]. Adolescent girls in South Africa often face a complex network of intersecting vulnerabilities, including a higher burden of unpaid domestic work and caregiving responsibilities within the household [79]. These gender roles often limit their access to educational opportunities and inflate their sense of responsibility, leading to increased stress and psychosocial strain. Furthermore, gender inequality in South Africa contributes to alarming rates of gender-based violence (GBV), with the country having some of the highest rates of intimate partner violence and femicide in the world [80].

Beyond this, three types of risk variables emerged among the largest predictors: Firstly, parental mental health and alcohol use. During early childhood, maternal depression emerged as an important predictor of higher levels of internalising symptoms during adolescence. Studies have identified that exposure to a depressed caregiver can have significant and lasting effects on child and adolescent mental health [81, 82]. A depressed caregiver may often display less maternal responsiveness or sensitivity, and more intrusive behaviour towards their child [82], which may be particularly detrimental for early childhood development [83]. While there is some evidence that such associations are found in LMICs [82], findings from this study contributes to the understanding that exposure to a depressed caregiver can have lasting effects on adolescent mental health in an environment characterised by compounded risks associated with poverty.

Furthermore, current caregiver alcohol use during early adolescence predictor associated with increased internalising symptoms. Previous studies have suggested that caregiver alcohol use can result in emotional neglect, inconsistent parenting, and family dysfunction [84–86]. These factors can create a stressful and unstable home environment, which is known to be detrimental to adolescent mental health [86]. Therefore, alcohol interventions and management must be a priority and follow a multi-faceted approach that addresses both the individual challenges faced by caregivers and the broader social and economic factors that contribute to increased substance use.

A few predictors related to poverty, including house type, and other secondary risks, were associated with internalising symptoms. Living in an informal house serves as an indicator of poverty, and it can also act as a proxy for other compounding risk factors. symptoms. Adolescents in

such environments are exposed to environmental instability (e.g., inconsistent access to electricity, sanitation, and clean water) and social stressors (e.g., overcrowding in homes and lack of privacy).

Also, caregiver employment during early childhood emerged as a predictor, suggesting the potential protective role of a stable environment within the family. Stable employment may contribute to a nurturing, supportive, and stable environment for a child [87, 88]. The importance of employment should be considered not only for its economic benefits but also for its potential to contribute to a sense of accomplishment, which can positively impact household functioning [89]. These findings highlight the significance of socio-economic factors in affecting internalising symptoms and emphasises the need for policies and interventions that supports families' financial stability as research has shown that financial stability can be associated with fewer mental health problems during adolescence [90–92].

Food insecurity during early adolescence was found to be associated with higher levels of internalising symptoms. Insufficient access to adequate and nutritious food is often a secondary consequence of living in poverty and parental unemployment and can have a profound impact on the development and mental health of a child and adolescent [93–96]. Most studies assessing the effect of food insecurity on adolescent mental health are limited to cross-sectional analysis [95, 97]. The current finding contributes to our understanding of how food insecurity can affect adolescent mental health over time, which is especially relevant in the context of South Africa, where almost 20% of households have inadequate or severely inadequate access to food [98]. Implementing comprehensive strategies such as increasing access to adequate food, improving economic conditions, enhancing employment, pay standards and cash grants, and promoting community-based support services can mitigate against the negative effects of food insecurity on adolescent mental health [99, 100].

Exposure to violence in the community and home also emerged as a predictor of high levels of internalising symptoms. This is in accordance with previous research indicating that violence exposure predicts higher levels of mental health problems, including internalising symptoms [96–103]. Nearly 70% of adolescents in South Africa report having witnessed or been victims of violence [101], with many experiencing multiple forms simultaneously [102]. Improving violence prevention and providing appropriate support to individuals affected by violence are critical steps towards promoting mental well-being in adolescents. As such, school-based interventions, community programmes, and mental health services can play a crucial role in creating safe environments and helping adolescents cope with exposure to violence [103, 104].

Family and friend/peer support both emerged as predictors of lower levels of internalising symptoms, indicating their potential protective role against such symptoms. While these factors are universally recognised as important [105–108], their influence is particularly critical in contexts marked by high rates of poverty, unemployment and violence. In environments with limited social safety nets, family and peer support can serve as a buffer against stress and trauma [109]. Family support which emerged as a significant predictor, can provide a sense of security and belonging that can help adolescents cope with daily challenges [110]. Similarly, strong peer support fosters resilience by creating a safe space where adolescents can share experiences, feel a sense of belonging, and receive mutual encouragement [111].

A healthy self-esteem also emerged as a protective factor against internalising symptoms. Previous studies have also reported on the significance of self-esteem in relation to internalising symptoms [112] suggesting it acts as a buffer against the negative or adverse effects on mental health [113, 114]. However, it is of interest to note that in this context characterised by high deprivation, such commonly variables commonly found relevant in HIC contexts play a comparatively smaller role than poverty and other psychosocial risks.

Overall, the current findings highlight the importance of considering the cumulative impact of multiple risk factors, over time, in understanding and addressing internalising symptoms. This study provides insight into how different individual, social, and environmental factors affect internalising symptoms across different life stages, in a high-risk population. Interventions that target specific risk factors in isolation may not be as effective as those that adopt a holistic approach, considering the interrelationship among these factors. A recent South African study provided evidence that addressing multiple factors simultaneously (i.e., safe communities, food security, and government cash transfers) can lead to better mental health outcomes in adolescents [115]. However, outcome studies evaluating the effectiveness of interventions targeting multiple factors simultaneously, instead of single factors, remains limited [116].

## Limitations

First, this study utilised a small sample size, that is on the lower end of what is recommended for the usage of selection approaches such as the elastic net. It also meant that we were unable to perform a test-training split to validate the predictiveness of our model in a separate sample. As a result, we focused predominantly on inference and not predictions but would recommend future studies to replicate the current findings with larger samples. Second, we were

somewhat limited by currently available packages to perform both multiple imputation and variable selection, and were as such not able to set up nested k-fold cross-validation, which is more suitable for small samples [117]. Future studies should aim to address this by expanding current methods or adopting a full Bayesian approach. Third, we only looked at internalising problems in a broad manner. Future studies may explore pathways towards specific disorders (e.g., depression, anxiety, post-traumatic stress disorder). Fourth, ideally, we would have wanted more intermediate measures between early childhood and early adolescent outcomes in order to investigate potential pathways through which the selected predictors can potentially affect internalising symptoms. It is also important to note that the group were exposed to two interventions over time – the primary reason for the study initially. Although exposure to such interventions were controlled for, the interventions themselves may have impacted on the findings and the functioning of at least some of the participants. This would suggest that when generalising to the broader population who have not been exposed to trial interventions, the situation may be different – perhaps worse.

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**Data availability** No datasets were generated or analysed during the current study.

## Declarations

**Competing interests** The authors declare no competing interests.

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