Article in Press

Examining maternal health literacy as a mediator of the relationship between social vulnerability and caregiving practices for improving infant development

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Word Count: (excluding title page, abstract acknowledgments, declarations, funding etc.)	7223

Abstract

This study examined whether specific dimensions of maternal health literacy mediated the relationship between social vulnerability and maternal caregiving confidence, specifically breastfeeding self-efficacy and maternal beliefs about play, among 168 mothers of newborns in Soweto, South Africa. Social vulnerability was measured using an adapted Social Vulnerability Index, and structural equation modelling was used to assess direct and indirect associations between social vulnerability, maternal health literacy dimensions, and caregiving outcomes. Although most mothers in the sample were classified as socially vulnerable, material deprivation showed no direct association with breastfeeding self-efficacy or maternal beliefs about play. Three dimensions of maternal health literacy-engagement with healthcare providers, ability to find good health information, and ability to understand health information well enough to act-emerged as important pathways shaping mothers' confidence and caregiving beliefs. The ability to engage with healthcare providers and to find good information partially mediated the effects of social vulnerability, while the ability to understand health information was a strong direct predictor of both outcomes, independent of deprivation. These findings indicate that relational and interpretive literacy skills play a more critical role in shaping maternal confidence than structural disadvantage alone. Strengthening these health literacy skills through targeted interventions may enhance mothers' confidence in breastfeeding and in supporting healthy play and development in their children, even in contexts of socio-economic vulnerability.

Trial Registration Number: PACTR202202747620052

Key Words: parenting, early childhood development, breastfeeding, play, low-income context

Introduction

The 2017 Lancet Early Childhood Development Series estimated that approximately 250 million children, or 43%, under the age of five in low- and middle-income countries (LMICs) are at risk of not reaching their full developmental potential [1]. Early childhood is a critical period for physical, cognitive, and emotional growth, with maternal caregivers playing a central role in shaping these outcomes [2]. While South Africa is classified as an upper middle-income country [3], it suffers from a staggeringly high unemployment rate of 33,2% [4] with a Gini coefficient of 0.62[3], reflecting persistent disparities in wealth and low intergenerational mobility. This deep inequality leaves many communities, such as Soweto, in low-income circumstances, where women of reproductive age frequently encounter socio-economic barriers to accessing and applying essential health information [5,6]. These challenges can affect their caregiving practices and, ultimately, their children's health outcomes [7].

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Maternal health literacy (MHL), defined as "cognitive and social skills that influence a mother's motivation and ability to comprehend and apply health information for both her and her child's well-being", is a crucial determinant of positive child outcomes [8]. In low-income settings, where access to formal healthcare and educational resources is often limited, MHL becomes particularly important in shaping how mothers engage with essential health knowledge for child health, including infant feeding practices and early opportunities for learning through play. Higher MHL enables mothers to make informed decisions about infant nutrition, such as choosing to exclusively breastfeed, which is vital for preventing malnutrition, promoting healthy cognitive development, and reducing the risk of early childhood illnesses [9,10]. Conversely, lower MHL is frequently associated with poorer developmental outcomes in children, as mothers may struggle to interpret or follow health guidelines. This can lead to the premature introduction of solid foods or inadequate engagement in developmentally appropriate play, both of which can impair physical and cognitive growth [11,12]. In environments where socio-economic challenges are compounded by low health literacy, children are particularly vulnerable to poor developmental outcomes.

Women of reproductive age (15-49) in South Africa face multiple socio-demographic challenges that contribute to heightened social vulnerability [13]. This vulnerability, shaped by factors such as high unemployment [14], low wages, domestic violence [15], and material and relational hardships [16], is further compounded by living in overcrowded, multi-generational households [15, 17]. These social and physical stressors increase susceptibility to public health threats [13] and may limit the capacity of mothers to provide optimal caregiving. Health literacy could potentially serve as a critical resource in this context, equipping mothers with skills that might help them navigate health challenges and make informed decisions, even within socio-economic constraints [2]. While it has been shown that health literacy can bridge the effect of deficiencies in socio-economic status on adult and child health outcomes in European populations [18,19], there is limited evidence that examines this relationship in low-income settings.

The nutrition infants receive during their early months is essential for their physical and cognitive development. The World Health Organization [20] recommends exclusive breastfeeding for the first six months, providing benefits such as enhanced immune function, reduced risk of infectious diseases, improved cognitive development, and lower likelihood of diabetes, obesity, and cardiometabolic issues later in life [1, 21, 22,23]. Despite these advantages, exclusive breastfeeding rates remain low in sub-Saharan Africa, including South Africa, where only 32% of infants are exclusively breastfed to six months, despite 67% initiating breastfeeding shortly after birth [24,25]. A key factor influencing breastfeeding initiation and continuation is maternal breastfeeding self-efficacy, or a mother's confidence in her ability to breastfeed successfully [26,27,28]. In sub-Saharan Africa, mothers face various barriers that challenge exclusive breastfeeding practices, such as the need to return

to work, health complications, inadequate lactation support, and societal pressures [29 ,30]. These obstacles are compounded by insufficient support and education, limiting mothers' ability to breastfeed exclusively for the recommended duration. Given these challenges, improving breastfeeding self-efficacy is crucial, as mothers who feel empowered and supported are more likely to maintain exclusive breastfeeding practices, promoting better health outcomes for their children [22,31,32].

Similarly, maternal beliefs about play significantly influence child development [32,33,34]. Play, defined as engagement in enjoyable activities, serves as a primary method for children to participate in physical activity. The Nurturing Care Framework emphasizes responsive caregiving and early learning as essential components for optimal early childhood development, with interactive play playing a vital role in these processes [35]. Engaging in stimulating play activities during the first two years of life not only helps infants meet movement guidelines for healthy growth but also provides nurturing care that is crucial for emotional, cognitive, and motor development [36]. Through interactive play, infants actively explore and learn, strengthening cognitive skills and laying a foundation for later learning, with positive knock-on effects for their overall developmental trajectory [37,38]. Guidelines recommend that infants engage in a minimum of 30 minutes tummy time and floor-based play, while toddlers should partake in at least 180 minutes of active play daily [39,40]. However, in low-income settings, social and family structures, including high household density and a lack of safe play environments, hinder the ability to incorporate play into daily life [15,41]. Research indicates that mothers' perceptions of play directly influence their caregiving practices, emphasizing the importance of understanding these beliefs to promote healthier behaviours [42]. In higher-income countries, factors such as access to outdoor spaces, encouragement from caregivers, and household socioeconomic status are known to affect play behaviours [43,44,45]. In South Africa, opportunities for early learning in the home are scarce, are often exacerbated by poverty and social vulnerability, creating barriers to optimal caregiving practices [15].

Despite the broad applicability of the concept of social vulnerability across various domains, there are few studies both internationally and locally that examine the relationship between social vulnerability with caregiving practices for promoting early childhood development, and whether these relationships are mediated by MHL. Understanding these linkages in South Africa is important due to the poor socio-economic conditions and high rates of economic and social exclusion experienced by women in impoverished urban settings, which could collectively undermine child health and development outcomes. Therefore, this study explored whether social vulnerability is associated with the caregiving practices for promoting infant development, specifically 1) breastfeeding self-efficacy and 2) maternal beliefs about play; and whether MHL mediates these relationships among a group of mothers in an urban township setting.

Methods

This study was nested within the PLAY Love and You (PLAY) Study, a phase 1 trial aimed at enhancing infant development by fostering maternal self-efficacy through the utilization of behavioural feedback and supportive interventions [27]. The study was conducted in the township of Soweto, which is situated in the City of Johannesburg, South Africa. It is classified as an urban-poor area spanning 200 km^2, accommodating over 1.3 million people (6400/km^2). Surveys were administered by trained research assistants upon recruitment. Participants were provided with an information sheet and required to provide written consent prior to being enrolled. Inclusion criteria for this study required that mothers resided in Soweto, be aged 18 or older, served as the primary caregiver of the index child and had complete data for the exposure, outcomes and mediator. Approval for the trial (M220217) was obtained from the Human Ethics Research Committee of the University of the Witwatersrand, Johannesburg, South Africa. Further approval was also secured from the Research Committee of Johannesburg Health District (GP_202202_021). REDCap was used for secure data management, hosted on a Wits University server with encrypted data traffic, access controls, and comprehensive audit trails (https://www.project-redcap.org)[46]. This trial was registered with the Pan African Clinical Trials Registry (https://pactr.samrc.ac.za) on 10 February 2022 (identifier: PACTR202202747620052).

Measures

Outcome 1: Breastfeeding self-efficacy

Maternal breastfeeding self-efficacy was measured using the Breastfeeding Self-Efficacy Scale-Short Form (BSES-SF) [47] during the first month postpartum. This 14-item scale employs a 5-point Likert format, where each statement is prefaced by "I can always..." and responses range from 1 (not at all confident) to 5 (very confident). The statements cover various aspects of breastfeeding, such as whether the infant is perceived to be getting enough milk, proper latching, and the mother's emotional state and ability to manage breastfeeding. Higher total scores indicate greater confidence in breastfeeding. This tool has been employed to identify mothers at risk of stopping breastfeeding early [48]. The BFSE-SF has been validated globally and in a similar setting in South Africa [49]. In this study, the BSES-SF demonstrated excellent internal consistency (α = 0.98), confirming its suitability for evaluating breastfeeding self-efficacy in the population studied

Outcome 2: **Maternal beliefs about play**

Maternal beliefs about play were assessed using and adapted version of the Melbourne Infant Feeding, Activity and Nutrition Trial (InFANT) programme [50], which has been used in this context previously [51]. This data was collected at recruitment to establish a baseline assessment of participants' beliefs about the importance of movement and play, allowing for intervention before mothers adopt

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caregiving practices that may impede their infant's physical and cognitive development. The questionnaire explores the mother's beliefs, attitudes and intentions around their infant's physical activity (play), using a 24-item questionnaire with a 4-point Likert-type scale (0= strongly agree to 3 = strongly disagree) [52]. There are 7 factor variables including play knowledge, views on children's play, play optimism, self-efficacy for promoting play, future expectations around infant's physical activity and TV viewing, and floor play concerns. Each factor score is generated by calculating the mean score within each factor, where a higher score indicates higher agreement with the factor variable [52]. A total mean score was calculated. Scale reliability of the questionnaire for this study population showed good internal consistency (α = 0.89), confirming that it is an appropriate measure for assessing maternal beliefs about play in this population.

Exposure variable: **Social Vulnerability**

To capture social vulnerability as a construct, we considered the United States Centres for Disease Control and Prevention (CDC) [53] social vulnerability index (SVI) which includes: 1) socioeconomic status, 2) household composition and disability 3) minority status and language and 4) housing and transportation [53] as per previous research in this context [13]. For the purpose of this study, we adapted the SVI by including a social support variable, and by excluding 'minority status and language' given the racial profile and majority status of the participants. Given the complexity of the variables and the differing relative contribution of each to the concept of social vulnerability in our context, we then used Principal Component Analysis (PCA) to derive a social vulnerability score for each participant (the methods used are described in the Statistical Analysis section). Details on the methodology used for collection of each variable included in the PCA are provided below.

1)   Socioeconomic status

Income, employment, and education level are normally included in this domain of SVI. Given sensitivities around assessing income and the level to which this variable is subject to change, we substituted income and poverty measures with a household asset score derived from a set of 13 commonly owned items. These items include electricity, fridge, stove, vacuum cleaner, washing machine, satellite TV, DVD player, motorcar, TV, landline telephone, cell phone, computer/laptop/tablet, and internet access. This selection has been proven to play a central role in assessing household economic status and is known to be responsive to changes over time [54,55]. This asset index was based on standard items used in the Demographic and Health Surveys household questionnaire (available at: www.measuredhs.com). We defined unemployment among participants as those who were neither currently employed nor engaged in any educational pursuits. We assessed education level by asking participants whether or not they had completed secondary schooling.

2)   Household Composition/Disability

We examined the ages of participant's household members focusing on vulnerable groups and captured data on the number of children under 18 years old. Additionally, we considered how much assistance mothers received from the father of the index child. We also included instances of disability when participants reported living with someone who has a significant disability.

3)   Housing and transport

We calculated household density by dividing the number of household residents who stayed in the home most nights over the last 3 months by the number of rooms available for sleeping. In evaluating transportation, we considered if participants had access to a motorcar.

4) Social Support

The social support questionnaire assessed the perceived availability of help from family, friends, health care professionals and partners through seven questions, each with scaled response options. To create a composite score, responses were assigned numerical values and summed across all items, with higher scores indicating greater perceived support.

Mediator variable: Maternal health literacy (MHL) Dimensions

MHL was measured using the parent version of the Health Literacy Questionnaire (HLQ). This questionnaire covers nine dimensions of health literacy and has been validated in high-income and low-to-middle-income countries [56,57,58]. Scale reliability of the HLQ for this study population showed excellent internal consistency ($\alpha = 0.84$), confirming that it is an appropriate measure for assessing MHL in this population. Multiple question items measuring various dimensions of health literacy were used. The nine MHL dimensions are as follows: 1) feeling understood and supported by healthcare providers , 2) having sufficient information to manage my child's health , 3) actively managing my child's health , 4) social support for health, 5) appraisal of health information , 6) ability to actively engage with healthcare providers,7) navigating the healthcare system , 8) ability to find good health information and 9) understand health information well enough to know what to do [58]. Each dimension was analysed separately as a continuous variable (mean of included item scores).

Statistical analysis

Data were cleaned and analysed using Stata® (Version 18.0, StataCorp, College Station, TX, USA) for Windows (v10). The distribution of the continuous variables (age, breastfeeding self-efficacy, maternal beliefs about play, maternal health literacy) was assessed using the sktest for skewness and kurtosis. All continuous variables were presented as means (standard deviation, SD) and categorical variables were presented as frequencies (%). Quality control of the data was carried out to remove participants with missing data. Of the (n=207) mother-infant pairs who were enrolled

in the study, (n=168) had complete exposure, mediator and outcome data and were included in this analysis.

To capture multidimensional aspects of social vulnerability, we applied PCA to ten household- and individual-level indicators: socioeconomic status (SES), household density, employment, number of children, educational attainment, presence of disability, motorcar ownership, father absence, lack of paternal support, and perceived social support. All variables were coded so that higher values reflected greater vulnerability, and continuous variables were standardized (z-scores) for comparability and integration with ordinal variables. Sampling adequacy was confirmed with the Kaiser–Meyer–Olkin statistic and Bartlett's test. Components were retained based on eigenvalues >1, scree plot inspection, and interpretability of loading patterns (salience ≥|0.30|). The first three components explained ≈49% of the variance (PC1 = 21%, PC2 = 16%, PC3 = 12%). Varimax rotation produced conceptually distinct indices which we named as follows: (1) Material Deprivation (driven by lower SES, less motorcar ownership, job insecurity, and higher housing density); (2) Family/Social Support Deficit (driven by father absence, lack of paternal help, more children, and lower perceived support); and (3) Health and Housing Strain (driven by higher household density, disability, more children, and lower social support). Standardized component scores (mean 0, SD 1) were saved using Stata's predict command and used as independent variables in subsequent models. Because our primary aim was to construct a single index of social vulnerability for use as a predictor, we emphasised theoretical coherence over maximizing explained variance, consistent with common practice in socioeconomic and deprivation indices (e.g., Filmer–Pritchett wealth index) [59]. Therefore, we chose the first component, Material Deprivation, as our indicator of social vulnerability, which we will refer to as Social Vulnerability going forward.

To identify which maternal HLQ subscales to retain, we screened each of the nine dimensions using simple linear regression with Social Vulnerability as the predictor. Three dimensions - (6) ability to actively engage with healthcare providers, (8) ability to find good health information, and (9) understanding health information well enough to know what to do - showed significant negative associations and were therefore included as mediators in the structural equation models (SEMs). A separate mediation model was then run with the continuous Social Vulnerability variable as the exposure and breastfeeding self-efficacy and maternal beliefs about play as the outcomes; with each of the three dimensions of the maternal HLQ separately (i.e.: six models in total) (see Appendices 1 and 2). Models were estimated in Stata 18 using maximum likelihood with full-information maximum likelihood (FIML) for missing data, and indirect, direct, and total effects were obtained via estat effects with delta-method standard errors.

Results

Table 2 shows the summary statistics for the sample of 168 mothers recruited 3 to 10 days post-delivery at two community clinics in Soweto. The average age of participants was 28.9 years (SD= 6.3). A large percentage of participants were unemployed (85%), with 54.80% of participants classified as having less than 8 of the 13 household assets assessed. Over a third (36.31%) of participants had not completed secondary school. High household density was experienced by 17.26% of participants, with 42. 86% of participants sharing their households with more than three children below the age of the 18. A very small number shared their homes with persons with disabilities (14.88%) and received no help in any form from the father of their child (12.5%), respectively.

The average breastfeeding self-efficacy score in the home environment was 64/70, suggesting that many mothers felt highly confident about breastfeeding, with only a few participants reporting notably lower self-efficacy levels. The median score of 57/70 for maternal beliefs about play suggest that, on average, respondents held relatively positive or strong beliefs about the importance of play, with most scores falling slightly above the midpoint of the scale. The mean MHL scores indicate generally high health literacy, with moderate scores on relational and informational aspects (feeling supported, sufficient information, managing health, social support, appraisal of information) but consistently higher scores on functional dimensions (engaging with providers, navigating the system, finding good information, understanding health information).

Table 2: Sample Characteristics (N=168)

	N/%	Mean (SD)/median [Q1-Q3]
Currently unemployed	126(85)	
Less than or equal to 8 assets per home	92(54.80)	
No Access to a motorcar	101(60.12)	
Less than 11 years of education	61(36.31)	
More than or equal to 4 residents per room	29(17.26)	
More than or equal to 3 children per HH	72(42.86)	
Share of households with a person with a disability	25(14.88)	
Father offers no help (1)	21(12.5)	
Age		28.9 (6.3)

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Social Support Score		5.17 (1.44)
Breast Feeding Self Efficacy		64.31(8.19)
Maternal Beliefs about Play		56.75(8.15)
Maternal Health Literacy Dimensions		
1)Feeling understood and supported by healthcare providers		3.12 (0.76)
2)Having sufficient information to manage my child's health		3.19 (0.72)
3)Actively managing my child's health		3.27 (0.68)
4)Social support for health		3.26(0.68)
5)Appraisal of health information		3.23 (0.68)
6)Ability to actively engage with healthcare providers		4.43(0.58)
7)Navigating the healthcare system		4.42(0.57)
8)Ability to find good health information		4.42(0.57)
9)Understand health information well enough to know what to do		4.49 (0.56)

Models 1a, 1b and 1c: Breast feeding self-efficacy

Table 3: Breast feeding self-efficacy direct, indirect and total effects

Effect	Coefficient	Std. Error	z-value	p-value	95% CI
MHL: Ability to engage with healthcare providers					
Direct Effects					
Social Vulnerability → MHL (path a)	-0.07	0.03	-2.27	0.023	[-0.13, -0.01]
MHL HLQ → BFSE (path b)	5.20	1.04	5.00	<0.001	[3.16, 7.24]
Social Vulnerability → BFSE (path c)	0.55	0.41	1.33	0.183	[-0.26, 1.36]
Indirect Effect					
Social Vulnerability → MHL → BFSE	-0.36	0.17	-2.06	0.039	[-0.70, -0.02]
Total Effect					
Social Vulnerability → MHL → BFSE	0.19	0.44	0.44	0.658	[-0.66, 1.05]

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MHL: Ability to find good health information					
Direct Effects					
Social Vulnerability → MHL (path a)	-0.07	0.03	-2.18	0.029	[-0.13, -0.01]
MHL → BFSE (path b)	4.70	1.06	4.44	<0.001	[2.63, 6.77]
Social Vulnerability → BFSE (path c)	0.50	0.42	1.20	0.23	[-0.32, 1.33]
Indirect Effects					
Social Vulnerability → MHL → BFSE	-0.31	0.16	-1.96	0.05	[-0.62, 0.00]
Total Effect					
Social Vulnerability → MHL → BFSE	0.19	0.44	0.44	0.658	[-0.66, 1.05]
MHL: Understand health information well enough to know what to do					
Direct Effects					
Social Vulnerability → MHL (path a)	-0.07	0.03	-2.27	0.023	[-0.13, -0.01]
MHL → BFSE (path b)	3.30	1.12	2.95	0.003	[1.10, 5.49]
Social Vulnerability → BFSE (path c)	0.42	0.43	0.96	0.338	[-0.43, 1.26]
Indirect Effect					
Social Vulnerability → MHL → BFSE	-0.22	0.12	-1.80	0.072	[-0.46, 0.02]
Total Effect					
Social Vulnerability → MHL → BFSE	0.19	0.44	0.44	0.658	[-0.66, 1.05]

Across the three SEM models (see Appendix 1), social vulnerability showed consistent negative associations with maternal health literacy dimensions that, in turn, predicted BFSE. Higher social vulnerability was associated with reduced ability to engage with healthcare providers (β = –0.07, SE = 0.03, 95% CI: –0.13, –0.01, p = 0.023), and this pathway significantly mediated BFSE (indirect effect: β = –0.36, SE = 0.17, 95% CI: –0.70, –0.02, p = 0.039). Similarly, social vulnerability predicted poorer ability to find good health information (β = –0.07, SE = 0.03, 95% CI: –0.13, –0.01, p = 0.029), which was linked to lower BFSE through a marginally significant indirect pathway (β = –0.31, SE = 0.16, 95% CI: –0.62, 0.00, p = 0.050). Finally, the ability to understand health information well enough to know what to do was

positively associated with BFSE (β = 3.30, SE = 1.12, 95% CI: 1.10, 5.49, p = 0.003), although the indirect pathway from social vulnerability was not significant.

Model 2a, 2b and 2c: Maternal beliefs about play

Table 4: Maternal beliefs about play direct, indirect and total effects

Effect	Coefficient	Std. Error	z-value	p-value	95% CI
MHL: Ability to engage with healthcare providers					
Direct Effect					
Social Vulnerability → MHL (path a)	-0.07	0.03	-2.27	0.023	[-0.13, -0.01]
MHL → MBP (path b)	4.24	1.05	4.03	<0.001	[2.18, 6.30]
Social Vulnerability → MBP (path c)	-0.47	0.42	-1.12	0.264	[-1.29, 0.35]
Indirect Effect					
Social Vulnerability → MHL → MBP	-0.29	0.15	-1.97	0.048	[-0.58, -0.00]
Total Effect					
Social Vulnerability → MHL → MBP	-0.76	0.43	-1.76	0.079	[-1.61, 0.09]
MHL: Ability to find good health information					
Direct Effects					
Social Vulnerability → MHL (path a)	-0.07	0.03	-2.18	0.029	[-0.13, -0.01]
MHL → MBP (path b)	4.40	1.05	4.19	<0.001	[2.34, 6.47]
Social Vulnerability → MBP (path c)	-0.47	0.42	-1.13	0.26	[-1.29, 0.35]
Indirect Effect					
Social Vulnerability → MHL → MBP	-0.29	0.15	-1.93	0.053	[-0.59, 0.00]
Total Effect					
Social Vulnerability → MHL → MBP	-0.76	0.43	-1.76	0.079	[-1.61, 0.09]
MHL: Understand health information well enough to know what to do					
Direct Effects					
Social Vulnerability → MHL (path a)	-0.07	0.03	-2.27	0.023	[-0.12, -0.01]
MHL → MBP (path b)	2.76	1.11	2.47	0.013	[0.57, 4.94]
Social Vulnerability → MBP (path c)	-0.58	0.43	-1.34	0.182	[-1.42, 0.27]
Indirect Effect (a×b)					

Social Vulnerability → MHL → MBP	-0.18	0.11	-1.67	0.094	[-0.40, 0.03]
Total Effect					
Social Vulnerability → MHL → MBP	-0.76	0.43	-1.76	0.079	[-1.61, 0.09]

Across the three SEM models (see Appendix 2), social vulnerability was consistently negatively associated with health literacy dimensions that, in turn, predicted MBP. Higher social vulnerability was linked to reduced ability to engage with healthcare providers (β = –0.07, SE = 0.03, 95% CI: –0.13, –0.01, p = 0.023), which significantly predicted lower MBP through an indirect pathway (β = –0.29, SE = 0.15, 95% CI: –0.58, –0.00, p = 0.048). Similarly, social vulnerability predicted poorer ability to find good health information (β = –0.07, SE = 0.03, 95% CI: –0.13, –0.01, p = 0.029), which was associated with weaker MBP through an indirect pathway that approached significance (β = –0.29, SE = 0.15, 95% CI: –0.59, 0.00, p = 0.053). Finally, the ability to understand health information well enough to know what to do, was positively associated with MBP (β = 2.76, SE = 1.11, 95% CI: 0.57, 4.94, p = 0.013), although the indirect pathway from social vulnerability was not significant (p = 0.094).

Discussion

This study found that social vulnerability, was not directly associated with BFSE or MBP. Instead, three MHL dimensions; the ability to engage with healthcare providers, the ability to find good health information, and the ability to understanding health information well enough to know what to do- emerged as key mediators influencing maternal confidence and caregiving beliefs.

The ability to engage with healthcare providers significantly mediated the effects of social vulnerability on both outcomes. Low scores in this dimension reflect mothers who approach healthcare passively, accept information without clarification, and struggle to advocate for themselves [58]. Similarly, the ability to find good health information was negatively affected by social vulnerability and showed an indirect association with BFSE and MBP. Mothers with low scores in this domain often cannot access information when needed and rely on others, limiting their agency [58]. Finally, understanding health information well enough to know what to do was strongly associated with both BFSE and MBP. This dimension reflects interpretive skills such as reading and comprehending medical instructions [58], which are strongly influenced by educational attainment.

Studies across diverse contexts consistently show that women in lower socio-economic groups face greater barriers to accessing credible health information [18; 61]. In other LMICs, such relational barriers have been shown to limit confidence in breastfeeding and reduce the value placed on play as a developmental activity, highlighting how empowerment in provider interactions is central to caregiving [62;

63]. In Sub-Saharan African settings, mothers with stronger engagement skills are better able to secure information and resources, consistent with evidence that empowered women achieve improved maternal and child health outcomes [64-68]. Studies in both the Netherlands and South Africa have shown that lower levels of schooling limit mothers' ability to understand and apply health information [69; 70]. In South Africa, research shows that written information paired with pictorial material is most effective for promoting comprehension [71; 72] underscoring the importance of contextually appropriate tools for strengthening functional health literacy in this population.

Taken together, these findings indicate that social vulnerability does not directly determine maternal caregiving confidence or beliefs, but that the effect of such vulnerability on relational, information-seeking, and interpretive literacy skills consistently shape how mothers perceive their ability to care for their children. Strengthening MHL may therefore represent a direct and actionable strategy for enhancing maternal confidence in breastfeeding and in supporting play, irrespective of socio-economic vulnerability. Unlike structural determinants of inequality, which are often difficult to address in resource-constrained health systems [18], MHL can be improved through targeted interventions. Critical service entry points include preconception, antenatal, and women's health care visits, when mothers are most likely to engage with information, make preventive health decisions, and interact with providers [56]. Evidence demonstrates that antenatal classes, home visits by community health workers, and pictorial health education materials are effective, low-cost strategies to improve MHL [73 –75] and can promote mothers' confidence and positive beliefs about their caregiving role [76].

The absence of strong mediating effects of MHL dimensions on the relationship between material deprivation and caregiving practices was notable. While the ability to engage with healthcare providers and to find good health information partially mediated the effect of deprivation on mothers' confidence in breastfeeding and their beliefs about play. In particular, understanding health information well enough to act was strongly associated with mothers perceived confidence in breastfeeding and their belief in the importance of play, but this dimension was not associated with social vulnerability. This indicates that some literacy skills may operate independently of socio-economic vulnerability, directly supporting how mothers think and feel about their caregiving abilities.

Although social vulnerability comprised multiple indicators, this was not an exhaustive set. Key indicators such as household members over 65, minority status, and language were not included. While poverty and income were substituted with SES as a more neutral indicator of socioeconomic position, the absence of English proficiency is notable, as this has been linked to health literacy in multiple studies [77] and may be a major determinant of MHL in contexts where medical communication is largely in English.

A further limitation concerns measurement. The Health Literacy Questionnaire (HLQ) has demonstrated strong validity and reliability across diverse settings, including South Africa [53,68], yet the unexpectedly high scores observed across dimensions may reflect social desirability bias from staff-administered (oral) surveys, reference-group effects, or limited contextual relevance of certain constructs. The maternal beliefs about play measure, adapted from the InFANT programme, has not been formally validated in South Africa and requires further cultural adaptation. Finally, while the sample of 168 mothers provided adequate power to detect moderate-to-large effects (Cohen′s d ≈ 0.46–0.70), it may have been underpowered for smaller associations, underscoring the need for larger samples and inclusion of behavioural outcomes in future research.

Conclusion

These findings show the potential of targeted interventions to strengthen skills and enhance mothers' confidence in their ability to breastfeed and encourage healthy play and movement in their children. Future work should test competing or parallel mediation models to capture the broader mechanisms linking social vulnerability to caregiving and incorporate behavioural outcome data to move beyond maternal perceptions and assess how confidence and beliefs translate into actual practices.

Declarations

Ethics approval and consent to participate

Approval for the trial (M220217) was obtained from the Human Ethics Research Committee of the University of the Witwatersrand, Johannesburg, South Africa. Additional approval was granted by the Research Committee of the Johannesburg Health District (GP_202202_021). All participants received written and verbal information about the study and provided informed consent prior to participation. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing Interests

The authors report there are no competing interests to declare.

Authors' contributions

AP, SN and LS were involved in conceptualisation. LS cleaned, analysed and interpreted the data with input from AP and RD. LS wrote the manuscript with input from AP, CH and FB. All authors read and approved the final manuscript**.**

Acknowledgements

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Biographical notes

Lauren Stuart

Lauren Stuart is a development studies researcher and Postdoctoral Fellow at the DSI-NRF Centre of Excellence in Human Development at the University of the Witwatersrand. She earned her doctoral degree in 2022 from the University of Johannesburg. Her work focuses on promoting social justice and enhancing opportunities for individuals to realize their full potential through income support, social protection, and active labour market programs. Lauren's research incorporates social theories such as the capabilities approach, gender theory, and social justice theory, which has also guided her supervision of student dissertations. She has collaborated with UNRISD, analysing the social impacts of social protection policies on marginalized women and low-income workers. Her expertise extends to Participatory Monitoring and Evaluation (PM&E) techniques, including baseline surveys, performance indicators, and beneficiary assessments, as well as the application of multiple case study design.

Claire Hart

Claire Hart is a community-based psychologist and postdoctoral fellow at the South African Medical Research Council's Developmental Pathways for Health Research Unit (SAMRC DPHRU). Her clinical expertise as a psychologist, combined with a robust foundation in evidence-based research, underpins her approach to

understanding the developmental origins of health and guiding the design and implementation of health interventions across various life stages.

Rachana Desai

Rachana Desai is a behavioural scientist with 8 years' experience in researching adolescent risk and protective behaviours. She has a strong interest in examining the interplay between online and offline worlds on child and adolescent behaviour and development. With experience in managing cohort studies at WITS University and national surveys at the Human Sciences Research Council, Rachana is skilled analysing complex qualitative and quantitative data related to tobacco use, non-communicable diseases, pregnancy and disabilities in low socio-economic groups. At WITS, Rachana led the MZANZI teen lab – a teen space where she co-designed several adolescent friendly data collection approaches and tools including storytelling and observational approaches to capture lived experiences. Here, she developed her passion for methodological innovation. Rachana is also a skilled science communicator and was a finalist in South African FAMLAB competition (2022). Her contribution to policy includes her involvement in the Child Gauge, a policy document prioritizing the rights of children concerning adolescent mental health and digital spaces. This output led to her participation in a range of public engagement activities such as podcasts, radio and television interviews and features in national newspaper articles that have been widely recognized throughout the African continent.

Shane A Norris

Shane Norris is a Professor of Global Health at the University of Southampton and at the University of the Witwatersrand, Johannesburg, South Africa where he leads a team part of the South African Medical Research Council's Developmental Pathways for Health Research Unit. Shane's research focuses on life course epidemiology with a specific interest in the development of intergenerational risk for non-communicable disease. His expertise includes nutrition and body composition across the life course and longitudinal-cohort and trial study methodologies. Shane is working with several scientists across Africa to both better understand and develop interventions that improve maternal and child health outcomes.

Fiona Bennin

Fiona Bennin is a trained paediatric Occupational Therapist with a master's in public health. Her research background is in clinical trials and implementation science and currently works in HIV prevention as a socio-behavioural scientist in South Africa. Fiona is passionate about promoting healthy movement behaviours, active play and physical activity in infants and children, all topics which were explored in her PhD. Skilled in mixed methods research, she also has a strong interest in behaviour change, social determinants of health, non-communicable diseases, and implementation science.

Helene Theunissen

Helene Theunissen holds an MPH degree in Epidemiology & Biostatistics and is currently working towards obtaining a PhD.   She has worked as a Registered Dietitian in both the private as well as the public sector. In recent years, she acquired research experience primarily in maternal and child health in South Africa. Her research interests include public health nutrition and the significance of the "First 1000 days", with a particular focus on non-communicable diseases and obesity, as well as interventions addressing these.

Alessandra Prioreschi

Alessandra Prioreschi is a senior researcher whose most recent work, conducted during her time at the Developmental Pathways for Health Research Unit (DPHRU) in Soweto, South Africa, focuses on the PLAY study (Play, Love, and You). This randomized controlled trial (RCT) aims to enhance infant development by fostering maternal self-efficacy. The study targets maternal mental health, responsive caregiving, nurturing care, breastfeeding, and play and development through a supportive intervention during the first 12 months of life. In addition to the PLAY study, Alessandra was involved in various other projects at DPHRU. Her past research includes leading a large-scale, long-term, multi-country preconception intervention to reduce childhood obesity and investigating physical activity measurement, determinants, and correlates, particularly movement behaviours—physical activity, sleep, and sedentary behaviour—in the first two years of life. Her postdoctoral work explored physical activity levels during the first 1,000 days of life (pregnancy, postpartum, and infancy) and their effects on growth, development, adiposity, and long-term health, in collaboration with the MRC Epidemiology Unit. Alessandra's doctoral research, completed at the University of the Witwatersrand, examined the impact of physical activity on disease activity in rheumatoid arthritis patients, showcasing her strong foundation in exercise physiology.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

AP, SN and LS were involved in conceptualisation. LS cleaned, analysed and interpreted the data with input from AP and RD. LS wrote the manuscript with input from AP, CH and FB. All authors read and approved the final manuscript.