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Maternal HIV does not affect resiliency among uninfected/HIV exposed South African children from birth to 5 years of age

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Abstract

Objective: Examine resiliency among a South African population cohort of children of mothers living with HIV (MLH) and mothers without HIV (MWOH) in low-income townships over the first 5 years of life.

Design: A cluster randomized controlled intervention trial evaluating child resiliency and the effects of home visiting in township neighborhoods from pregnancy through 5 years postbirth.

Methods: The population of pregnant women in 24 matched neighborhoods were recruited and randomized by neighborhood to a standard care condition ($n = 594$) or a paraprofessional home visiting intervention condition ($n = 644$). Mothers and children were assessed at 2 weeks, 6, 18, 36, and 60 months postbirth (92 – 84% follow-up; 10.2% mortality). Resilient children were identified based on consistently meeting global standards for growth, cognitive functioning, and behavior. Maternal HIV status ($n = 354$ MLH; $n = 723$ mothers without HIV MWOH), intervention condition, maternal risks, caretaking, sociodemographic characteristics, and neighborhood were examined as predictors of child resiliency over time using analysis of variance, chi-square analyses, and Fisher's exact tests, where appropriate.

Results: None of HIV-seropositive children ($n = 17$) were resilient; 19% of 345 HIV- exposed but uninfected children of MLH were resilient, a rate very similar to the 16% among MWOH. Resiliency was significantly associated with lower income, food security, not having a live-in partner, and the absence of maternal risk (i.e., not being depressed, using alcohol, or being a victim of intimate partner violence). Being randomized to a home visiting intervention, maternal

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Trial registration: [ClinicalTrials.gov](https://clinicaltrials.gov) registration .

Conflicts of interest

There are no conflicts of interest.

breastfeeding for at least 3 months and attending a preschool crèche were also unrelated to resiliency. Although matched pairs of neighborhoods had similar rates of resilient children, resiliency varied significantly by neighborhood with rates ranging from 9.5 to 27%.

Conclusion: We set a new standard to define resiliency, as consistently recommended by theoreticians. Although seropositive children are not resilient, uninfected children of MLH are as resilient as their peers of MWOH. Typical protective factors (e.g., home visiting, breastfeeding, preschool) were unrelated to resiliency over the first 5 years of life.

Keywords

child health; home visiting; longitudinal analyses; mothers with HIV; resiliency

Introduction

Resiliency has been defined in a number of ways, but most consistently as successful coping over time, especially following adverse events that threaten children's development [1,2]. Yet, almost all research on childhood resiliency is based on cross-sectional samples of children in high-income countries (HIC) [3]. Only a few recent studies consider longitudinal patterns of behavior as is consistently recommended [1,2,4–6], and only one in a low and middle-income country (LMIC) [7]. Optimally, resiliency is defined based on physical growth and cognition, as well as emotional and behavioral adjustment [1].

Children growing up in a LMIC are at particular risk for not meeting their developmental potential. For example, about 44% (29.4 million) of children aged 3–4 years old experience low cognitive and/or socioemotional development in sub-Saharan Africa [8]. In contrast, only 20% of children in the United States are considered non-resilient [9]. The rates of South African children who do not meet their potential is close to the rate of 43% among refugee children in the United Kingdom [10]. The current study examines resiliency in a population cohort of South African children through their first 5 years of life, and uses a multidimensional approach to measure. Resiliency is defined on the basis of physical growth, cognitive, and behavioral markers. These characteristics are monitored at six different points in these early years.

Having longitudinal data allows us to examine children's resiliency when challenged by maternal health risks and the consequences of poverty. Young South African women have an 8% HIV incidence per year [11], resulting in about 26% of pregnant women testing seropositive for HIV [11]. Although children who acquire perinatal HIV are at high risk of early death, poor growth, and cognitive deficits, only about 2% of children of mothers living with HIV (MLH) become seropositive [12,13]. Yet it is unclear whether, how, and to what degree that the health and well being of HIV-exposed, but uninfected children of MLH is derailed. Having multiple observations on a population sample from matched neighborhoods allows us to examine how and whether children of MLH are affected. In particular, resiliency can be examined among children born to MLH compared with their peers born to mothers without HIV (MWOH) living in the same neighborhoods and born in the same period. Although the uninfected children of MLH do not acquire HIV, they begin life with immunological stressors (for review, see [14]). A recent review suggests that, despite

widespread maternal antiretroviral therapy in HIC, infants exposed to HIV *in utero* have impaired immune function compared with HIV-unexposed infants [15,16]. Less is understood about the health of exposed but uninfected children in LMIC [14]. Furthermore, MLH must adhere to lifelong medical regimens that can lead to financial burdens, physical illnesses, stigma, and discrimination [11]. MLH are also more likely to be depressed and to abuse alcohol, compared with MWOH [17,18]. Given these challenges, we hypothesize that fewer of the children of MLH may be resilient than those of MWOH.

Even though alcohol use and depression are more common among MLH, they are also prevalent among MWOH (19–36%) [19,20]. These maternal risks increase the probabilities of chronic illness, socioemotional challenges, and economic difficulty over the lifespan [21]. Yet, almost all families in peri-urban townships live in austere poverty. For example, 40% of families experience food insecurity, 25% intimate partner violence (IPV), and unemployment is typical, as is raising children without a partner. These maternal risks, as well as being a low birth weight infant (17%), low rates of exclusive breastfeeding (4%) and general malnutrition, put infants at lifelong risk for delays in growth and cognitive development [22–24]. Finally, having an unsupportive partner, or even one who verbally or physically abuses his partner, places children at long-term risk. At the very least, these children have daily stressors coping with unpredictable and chronically stressed parents. Therefore, we hypothesize that indicators of poverty, IPV, and maternal alcohol use and depression are negatively associated with child resiliency. Living with HIV can further magnify these risks associated with poverty and have an even greater impact on children of MLH compared with MWOH.

There are buffering factors which can also protect children. Mothers are typically the key source of protection for their children. Children with mothers who are more educated, those who have the financial and emotional support of a partner, and those with the personal abilities to exclusively breastfeed and enroll their children in preschool are likely creating opportunities and resources that their children can use later in life [25–27]. In particular, breastfeeding and attending preschool have been repeatedly found to be advantageous in HIC [27–29]. We hypothesize that these resources are likely to be associated with having more resilient children, especially among MLH when compared with MWOH.

Paraprofessional home visiting has been demonstrated to be an effective intervention that improves child outcomes [19,30,31]. However, evaluations have typically been focused on a single outcome and not for sustained for long periods in LMIC [30]. In the current study, a cluster randomized controlled intervention trial (RCT), we evaluate the child and maternal outcomes associated with home visiting over time [11,30–32]. Benefits of home visiting include higher rates of exclusive breastfeeding, increased adherence to tasks to prevent vertical HIV transmission for MLH, having infants with better growth trajectories, less maternal depression at 3 years, and less maternal alcohol use at 5 years among households receiving home visiting in contrast to those not receiving visits [30,33,34]. The current secondary analysis of this longitudinal RCT study allows us to examine how maternal risks, as well as protective factors, including a home visiting intervention, influence the development of resiliency in children among MLH and MWOH.

Methods

The Institutional Review Boards of the University of California Los Angeles and Stellenbosch University approved the study, whose methods have been published [14]. All mothers provided written, voluntary, informed consent. Three independent teams conducted the assessment, intervention, and randomization and data analyses.

Participants

Neighborhood clusters ($N=24$) of 450–600 households were identified and matched based on the housing type, presence of electricity, water, sanitation, size and density, the number of illegal, informal alcohol bars, child care resources, distance to clinics, and the length of residence. Matched neighborhoods were randomized, resulting in 12 standard care neighborhoods ($n=594$ mothers) and 12 neighborhoods in the home visiting condition ($n=644$ mothers). By birth, 69 mothers had miscarried or children died in childbirth; another 34 children died within the next 18 months (comparisons of households in which a child died compared with those who did not die are available on request).

Township women conducted house-to-house visits from May 2009 to September 2010 to identify and recruit all pregnant women ($N=1238$); only 2% refused participation. Assessments were conducted at a township research office. Follow-up assessments were conducted by interviewers (also local township women) at 2 weeks postbirth (92%), 6 (87%), 18 (91%), 36 (85%), and 60 months postbirth (83%). Our exclusion criteria for this study's analyses included: maternal/child death ($n=127$, 10.2%); having a child's z -score above 3 or below -3 for height-for-age z -scores (HAZ) ($n=262/5048$ observations, 5.2%) and/or weight-for-age z -scores (WAZ) ($n=107/5048$ observations, 2.1%); and twin and triplet births, incomparable children ($n=13$).

Measures

Child resiliency—Children were considered 'resilient' at each assessment if their developmental scores were within two SDs from the standardized mean scores for each variable.

Growth: Trained and certified interviewers weighed children and measured their height. Anthropometric data were then converted to z -scores based on the WHO's age-adjusted norms [33]. A z -score below -2 for HAZ was considered stunted and below -2 for WAZ was considered malnourished [34]. For growth, a HAZ and WAZ consistently higher than -2 at each assessment was considered resilient.

Cognition: At 18 months postbirth, we assessed cognitive and motor development using the Bayley Scale of Infant Development (BSID), a scale that has been shown to be reliable and valid in multiple settings [35]. A total score equal to or above 85 is within one SD of the standardized mean and was classed resilient [36]. The Peabody Picture Vocabulary Test (PPVT) [37] was administered at 36 and 60 months, using a form adapted for South Africa; standardized scale scores for each age were calculated and those within one SD were considered resilient [38]. At 60 months, cognitive abilities were assessed using the Mental

Processing Index (MPI) of the Kaufman Assessment Battery for Children (KABC). This index has shown to be a valid, reliable, and fair measure of children's childhood cognitive abilities in multiple settings and countries [39 – 41]. Scores above 1 SD from the standardized mean based on age on the BSID, MPI, PPVT, and KABC were considered resilient.

Behavior was rated at 36 and 60 months by parents using Achenbach's (1992) preschool Child Behavior Checklist (CBCL), a 99-item questionnaire rating their children's comportment on a 0–2 scale; a total score below 52.2 and a score below 16.9 on the aggressive scale are healthy [42,43]. Children within this range at 36 and 60 months were considered resilient; if outside of this range, they are labeled non-resilient. The Strength and Difficulties Questionnaire (SDQ) was also administered at 36 and 60 months; this is the sole measure used in most studies to assess resiliency [44,45]. A total SDQ score less than or equal to 19 and a prosocial behavior subscale score greater than or equal to 5 is considered resilient.

Maternal measures—Maternal measures were reported at each assessment. *HIV status* was self-reported by mothers. A MLH was defined as a mother that reported a positive HIV status at any study assessment. HIV status is also reflected on the child's clinic road-to-health card, which was checked at each assessment.

Demographic characteristics included current living location, household members, number of adults, and the presence of a live-in partner or husband. *Economic resources* were identified as formal housing (vs. an informal shack), years of maternal education, and monthly income (>2000 Rand and >5000 Rand). *Food insecurity* was reported as one item querying the number of days hungry in the last week from The Household Food Insecurity Access Scale (HFIAS). This item is highly correlated with the nine-item HFIAS in this sample [46].

Alcohol use: Problematic drinking (1, present or 0, not present) was defined based on whether a mother experienced heavy episodic drinking (i.e., bingeing) at least once a month, and responded yes to at least one symptom: needing to drink when waking; having others worried/complaining about your drinking; or forgetting events while drinking.

Depressive symptoms: The Edinburgh Postnatal Depression Scale (EPDS) [47] indicated depressed mood with scores more than 13 and at least 18 indicating probable major depressive disorder [48].

Intimate partner violence: Mothers reported whether they had been slapped, pushed or shoved, and/or threatened with a weapon by a current partner in the past 12 months.

Breastfeeding: Mothers self-reported whether they were exclusively breastfeeding for 3 and 6 months, separately.

Crèche: The mother self-reported whether the child attended crèche (preschool) at 36 and 60 months ('1' ¼ Attended crèche/preschool, '0' ¼ if not).

Intervention conditions

Standard care condition—Standard clinic care in Cape Town is accessible within 5 km of each study neighborhood. Each antenatal clinic provides comprehensive prevention of mother-to-child transmission (PMTCT) services, including HIV testing, maternal and child antiretroviral drugs, nevirapine at birth and PCR testing for infants. After birth, mothers and children transfer to primary healthcare clinics.

Home visiting condition—In addition to services in the standard care condition, home visits were conducted by paraprofessionals. Community health workers (CHWs) were selected from the township. Most had less than a high school education, good social, and problem-solving skills and were raising healthy children. CHWs were trained for 1 month in cognitive-behavioral change strategies to provide and apply health information about general maternal and child health, HIV, alcohol use, and nutrition. CHWs were certified and supervised biweekly with random observations of home visits. Eight health messages were delivered on HIV/tuberculosis prevention, PMTCT strategies and consequences of alcohol use/abuse, the importance of breastfeeding, and how to avoid malnutrition. CHW were to deliver these messages in at least four antenatal visits and four postnatal visits within the first 2 months of life. On average, CHWs made six antenatal visits (SD 3.8), five postnatal visits between birth and 2 months postbirth (SD 1.9), and until 6 months postbirth about 1.4 visits/month (range, 0.1–6.4 visits/ month). Visits were biannual after 6 months.

Data analyses

Key structural factors, maternal risks, and protective behaviors are measured over time, but collapsed for the current analyses (1, ever present or 0, not present at any assessment). We first compared the distribution of each child outcome measurements at each time point by resilient and non-resilient groups using *t* tests. We then examined key sociodemographic factors, maternal risk behaviors, protective behaviors, and migration indicators between resilient and non-resilient children, stratified by maternal HIV status.

Differences in maternal characteristics between resilient and non-resilient children stratified by maternal HIV status were assessed using chi-square or Fisher's exact tests for discrete variables, and *t* test or one-way analysis of variance for continuous variables. All analyses were conducted using Stata SE software version 15 (StataCorp LP, College Station, Texas, United States) [49].

Results

Defining resiliency

Children were 'resilient' if they were healthy at each of their reported assessments on physical growth, cognitive, and behavioral measures based on standardized scales. Resiliency is a time-independent, dichotomous variable (yes/no) over 5-years. The greatest number of children were classed non-resilient based on the scores on cognitive measures only (*n* 298); 83 children were excluded based on their measures of physical growth, and 36 were excluded based only on their behavioral maladjustment. Deficits in both cognitive and behavioral measures eliminated 141 children; physical and behavioral problems led to 14

children being eliminated; and physical and cognitive measures eliminated 218 children. More than 100 children had deficits on physical, cognitive, and behavioral measures on at least one assessment ($n \approx 102$).

Resiliency was examined separately for seropositive ($n = 17$, one died) and seronegative children ($n = 354$) of MLH. None of the seropositive children of MLH would have met the criteria as resilient, typically based on growth outcomes and cognitive deficits. Data comparing these HIV-positive children and uninfected, but HIV-exposed children are available upon request. Table 1 summarizes child developmental outcomes at each assessment between resilient ($n = 184$, 17.1%) and non-resilient ($n = 889$, 82.9%) children. Tables 2 and 3 summarize the baseline differences between MLH, reflecting 34% ($n = 360$) of the sample, and MWOH ($n = 713$). Among MLH, 18.9% of their children were resilient, similar to the rate of 16.3% among MWOH.

The developmental differences between resilient and non-resilient children confirm our definition of resilience. The HAZ was similar across resilient and non-resilient children over time. Resilient children have a significantly higher HAZ compared with non-resilient children at 6 months ($P < 0.01$) and 3-years ($P < 0.01$). The WAZs were significantly higher for resilient children compared with non-resilient children at 3-years ($P < 0.05$) and 5-years ($P < 0.01$). Resilient children had significantly higher scores on the Bayley Cognitive Composite Score ($P < 0.05$) and the motor composite score at 18 months ($P < 0.05$). Similarly, resilient children had higher scores on the PPVT at 3-years ($P < 0.01$) and 5-years ($P < 0.01$) and higher score on Kaufman MPI at 5-years ($P < 0.01$) compared with non-resilient children. Finally, mothers reported fewer behavior problems for resilient children than non-resilient children on the CBCL total score ($P < 0.01$) and the aggressive behavior subscale score at 3-years ($P < 0.01$) and 5-years ($P < 0.01$). The prosocial behavior subscale of the SDQ was significantly higher for resilient in contrast to non-resilient children at 3-years ($P < 0.01$) and 5-years ($P < 0.01$), as was the total SDQ score at 3-years ($P < 0.01$). These results confirm and reflect the criteria we used to define resiliency.

Maternal characteristics of resilient and non-resilient children

As shown in Table 2, mothers of both resilient and non-resilient children were similar in age (about 26 years old), years of education (10th grade), and type of housing at the baseline interview during pregnancy. Mothers of resilient children had lower incomes, that is, less than 2000 Rand ($P < 0.01$) and less than 5000 Rand ($P = 0.03$) than mothers of non-resilient children. Compared with mothers of non-resilient children, mothers of resilient children were less likely to report food insecurity among themselves ($P < 0.01$) or their children ($P < 0.01$). Furthermore, mothers of resilient children were less likely to be married or live with a partner ($P = 0.02$) and were less likely to live with three or more adults in household ($P < 0.01$) than mothers of non-resilient children.

Depressed mood occurred significantly less often among mothers of resilient children compared with mothers of non-resilient children ($P = 0.01$). However, self-reports indicating major depressive disorder were equally common among mothers of resilient and non-resilient children. IPV was significantly less common for mothers of resilient children compared with mothers of non-resilient children ($P = 0.02$). Mothers of resilient and non-

resilient children reported similar rates of problematic drinking. Exclusive breastfeeding for 3 and 6 months, and attendance at preschool were equal among mothers of resilient and non-resilient children. Mothers of resilient children were less likely to migrate to the rural area without their children than compared with mothers of non-resilient children ($P=0.02$).

Comparison between mothers living with HIV and mothers without HIV

Compared with MWOH, MLH were older ($F4.59, P<0.01$), had fewer years of education ($F5.84, P<0.01$), lower incomes (>2000 Rand, $P<0.01$; >5000 Rand, $P0.03$), experienced more food insecurity (number of mother hungry days in a week: ($F7.88, P<0.01$); number of child hungry days in a week: ($F8.53, P<0.01$), and had a household with less than three adults ($P<0.01$). We observed MLH had significantly higher rates of antenatal depressed mood ($P<0.01$), depressed mood (EPDS $>13, P<0.01$) and self-reports indicating major depressive disorder (EPDS 18, $P<0.01$) over time and more problematic alcohol drinking ($P<0.01$) than MWOH. Finally, fewer MLH breastfeed than MWOH for 3 months ($P<0.01$) and 6 months ($P<0.01$). No differences were found in marital status, formal housing, IPV, children attending preschool, and migration to the Eastern Cape.

Mothers living with HIV and mothers without HIV of resilient children

As seen in Tables 2 and 3, MLH of resilient children were older ($F10.68, P<0.01$), reported lower income (>2000 Rand, $P0.02$), and more often had informal housing ($P0.05$) compared with MWOH of resilient children. MLH of resilient children experienced more food insecurity than MWOH of resilient children (number of mother hungry days in a week, $F6.43, P0.01$; number of children hungry days in a week, $F4.66, P0.03$). Exclusive breastfeeding for 3 months was significantly lower among MLH with resilient children compared with MWOH of resilient children ($P<0.01$). MLH with resilient children were significantly less likely to exclusive breastfeeding for 3 and 6 months compared with MWOH of resilient children ($P<0.01$ and $P<0.01$, respectively).

MLH of resilient children had less problematic drinking than MWOH of resilient children ($P0.03$). MLH of resilient children were more likely to report indications of antenatal depressed mood ($P<0.01$), depressed mood ($P<0.01$), and major depressive disorder ($P<0.01$) than MWOH of resilient children over 5 years.

Mothers living with HIV and mothers without HIV of non-resilient children

MLH of non-resilient children reported lower income (>2000 Rand, $P0.02$) and greater food insecurity (number of mother hungry days, $F7.75, P<0.01$; number of children hungry days, $F11.51, P<0.01$) than MWOH of non resilient children. MLH of non-resilient children were more likely to report indications of antenatal depressed mood ($P0.04$), depressed mood ($P<0.01$), and major depressive disorder ($P<0.01$) than MWOH of non-resilient children over time. MLH of non-resilient children had experienced more problematic drinking than MWOH of non-resilient children ($P<0.01$). Finally, MLH of non-resilient children were more likely to report having migrated to the Eastern Cape without their children than MWOH of non-resilient children ($P<0.01$). There were no significant differences in the years of education, mothers' marital status, the number of

adults in household, rates of IPV, and migration to the rural Eastern Cape among MLH and MWOH of non-resilient children.

Resilient and non-resilient children of mothers living with HIV

MLH of resilient children had lower incomes (>2000 Rand, $P < 0.01$), were less likely to have three or more adults in their household ($P 0.03$) or to experience IPV ($P 0.03$) than MLH of non-resilient children. Exclusive breastfeeding was more common among MLH of resilient children at 6 months ($P 0.05$) and mothers had more often migrated to rural areas ($P 0.03$) than MLH of non-resilient children (Table 3). Maternal age, education, income (>5000 Rand), formal housing, food insecurity, marital status, depression, problematic drinking, exclusive breastfeeding up to 3 months, preschool attendance, and migration to rural Eastern Cape were not significantly different between MLH of resilient and MLH of non-resilient children.

Resilient and non-resilient children of mothers without HIV

MWOH of resilient children were more educated (10.8 vs. 10.4, $P 0.03$), had lower income (>2000 Rand, $P 0.01$), experienced food insecurity less often (maternal days insecure, $P < 0.01$; children's days insecure, $P < 0.01$), were less likely to live with three or more adults in their household ($P < 0.01$), or to have depressed mood ($P 0.01$) than MWOH of non-resilient children (Table 3). MWOH of resilient and non-resilient children were similar in age, marital status, indications of major depressive disorder, problematic drinking, child preschool attendance, the duration of exclusive breastfeeding, and migration to the rural Eastern Cape.

Resilient and non-resilient children based on neighborhood clusters

Resiliency was significantly different by neighborhood cluster ($P < 0.01$) (Table 4). Three neighborhood clusters had, on average, a low of 11% resilient children and one cluster had a high of 27%, with a mean of 17% across all neighborhoods. When further stratified by maternal HIV status (Table 5), coincidentally the highest and lowest rates of resilient children were among those the MWOH subgroup (6 and 29%, respectively). There were no significant findings between neighborhood clusters by resiliency outcome, HIV status or MLH only. There is a trend of significance among the MWOH group only ($P \frac{1}{4} 0.09$).

Discussion

Nearly one in five children in the townships of Cape Town, South Africa are resilient. The current study is novel both in the methodology used to define resiliency and the population examined. Theoretically, resiliency is defined as a lifelong process in which children cope effectively with deprivation or challenges over time, without showing developmental deficits. However, in practice, resilience is typically assessed using a measure of behavior at a single time point and almost always in HIC [2,3]. This study defines resiliency based on longitudinal observations over time on globally recognized standards of growth, cognitive development, and behavior. Despite facing significant adversities, 17% of children demonstrate positive developmental trajectories.

Surprisingly, uninfected children of MLH are as resilient as MWOH. MLH consistently have greater risks – lower breastfeeding rates, higher rates of depressed mood and problematic alcohol use than MWOH [19,20]. Yet, predictors of resiliency are similar across MLH and MWOH. These findings are unexpected and important. No infants who acquired HIV ($n = 17$, one child HIV died at 6 months) in the current sample met the study's definition of resilient. However, infants who are HIV- exposed but uninfected appear to have no long-term deficits, despite being exposed *in utero* to HIV.

Consistent with previous findings [12,16], maternal risk factors (depression, IPV, and problematic alcohol use) are negatively associated with child resiliency. However, typical markers of poverty are not consistently related to resiliency. Mothers who have resilient children have lower incomes – not more income, as would be expected. Although food security is associated with having more resilient children, other markers of poverty, such as years of maternal education and the percentage of mothers living in formal housing (vs. informal shacks), are not linked to resiliency. Also unexpected, mothers without live-in partners and fewer adults in their households are more likely to have resilient children. This may reflect that there are less crowding or less interpersonal conflicts in their household. However, this is only speculation, as we did not measure these family interactions.

Although there is a long history of linking breastfeeding to lifelong positive outcomes [17,18], exclusive breast-feeding is unrelated to resiliency in this study. In HIC, breastfeeding is associated with children's improved BMI, blood pressure, and cognitive functioning. However, in LMICs it is only linked with improved cognitive functioning [18]. We do not observe these benefits, however. Similarly, while attending a preschool crèche has major benefits in HIC [50], no such benefits appear in this study.

Finally, home visiting is also unrelated to childhood resiliency. In previous analyses of this cohort, intervention mothers report significantly lower rates of depression at 3 years, and less alcohol use and problematic drinking at 5 years postbirth [51]. There are also significant early benefits in children's growth associated with home visiting, and MLH's adherence to PMTCT tasks is 50% higher [33,34]. However, mothers and children receive limited visits after the child reaches 6 months. We have shown repeatedly over time that interventions do not serve as inoculations – protecting children indefinitely from risks. The loss of impact of home visiting suggests extending these interventions into early childhood to support early learning experiences that may not be currently available in the local preschools. The quality of early learning experiences is likely an important dimension to consider when investing in children's development both in the home and at school.

The current measure of resiliency extends the literature by considering multiple developmental domains over the first 5 years of life in children living in a LMIC. It would be important to identify children who show resilient developmental patterns based on their physical growth alone, compared with those who cognitive development or behavioral adjustment appear strong. In this article, we narrowly define resiliency as showing all three characteristics. Future articles will examine fine-grained analysis of resilience in different domains.

The high variation in resiliency across neighborhoods may be more important than linking resiliency to breastfeeding or preschool. These findings are key and suggest the importance of future longitudinal, multidimensional studies of resiliency that include multiple geographically defined communities that reflect larger variations in sociometric status. This study suggests that building resilient neighborhoods may be a critical intervention to support children living in poverty.

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Table 1.

Summary of the child characteristics over the first 5 years of life grouped by children labeled ‘Resilient’ and children who are ‘Non-Resilient’.

	Resilient children, <i>n</i> ¼ 184, 17.1%		Non-resilient children, <i>n</i> ¼ 889, 82.9%		Total, <i>n</i> ¼ 1073
	Mean	(SD)	Mean	(SD)	Mean (SD)
Growth measurements					
Height-for-age z-score					
Postbirth	-0.09	0.96	-0.23	1.19	-0.21 1.15
6-months ^M	0.15	1.10	-0.18	1.27	-0.13 1.25
18-months	-0.43	0.88	-0.53	0.97	-0.52 0.96
36-months ^M	-0.80	0.76	-1.19	0.99	-1.17 0.98
60-months	-0.36	0.78	-0.55	0.96	-0.54 0.95
Weight-for-age z-score					
Postbirth	0.15	0.92	0.11	0.99	0.12 0.97
6-months	0.46	1.04	0.51	1.09	0.50 1.08
18-months	0.29	1.10	0.27	1.07	0.27 1.07
36-months ^{MM}	0.47	0.79	0.14	0.95	0.15 0.95
60-months ^{MM}	0.30	0.86	-0.02	0.97	0.004 0.97
Cognitive function					
Bayley Cognitive Composite Score					
18-months ^{MM}	105.28	15.02	99.69	13.97	100.12 14.11
Bayley Motor Composite Score					
18-months ^{MM}	108.56	14.41	103.41	12.28	103.80 12.51
Peabody Picture Vocabulary Test Score					
36-months ^M	29.67	6.63	19.53	7.85	19.83 8.00
60-months ^M	76.91	11.98	61.32	18.07	62.04 18.13
Kaufman MPI Standard Score					
60-months ^M	95.90	8.46	82.75	11.07	83.35 11.30
Behavior					
CBCL Aggressive Behavior Subscale Score					

	Resilient children, <i>n</i> ¼ 184, 17.1%		Non-resilient children, <i>n</i> ¼ 889, 82.9%		Total, <i>n</i> ¼ 1073	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
36-months <i>M</i>	8.42	3.66	13.20	7.30	12.89	7.21
60-months <i>M</i>	6.23	3.68	11.01	8.26	10.73	8.14
Total CBCL Score						
36-months <i>M</i>	33.17	10.14	49.40	23.47	48.36	23.18
SDQ Prosocial Behavior Subscale Score						
36-months <i>M</i>	8.08	1.48	7.28	2.20	7.33	2.17
60-months <i>M</i>	9.05	1.38	8.04	2.04	8.10	2.02
Total SDQ Score						
36-months <i>M</i>	7.55	3.05	9.91	4.75	9.76	4.69

CBCL, Child Behavior Checklist; MPI, Mental Processing Index; SDQ, Strength and Difficulties Questionnaire.

M *P* value <0.01.

MM *P* value <0.05.

Table 2.

Sociodemographic factors, maternal risk behaviors, protective behaviors, and migration, grouped by mothers living with HIV or without and mothers with resilient children or not.

	MLH n¼360				MWOH, n¼713				R only, MLH vs. MWOH, n¼184	HIV only, n¼1073	Non-R only, MLH vs. MWOH, n¼889	
	Resilience, n¼68, 18.9%	Non-Resilience, n¼292, 81.1%	Total MLH	Resilience, n¼116, 16.3%	Non-resilience, n¼597, 83.8%	Total MWOH	R ^a , n¼1073					
	n	%	n	%	n	%	n	%	n	%	n	%
Sociodemographic factors												
Maternal Age (mean, SD)	27.9 ± 5.5		26.9 ± 5.2		25.1 ± 5.5		26.2 ± 5.7		26.0 ± 5.7		<0.01	
Education (mean, SD)	10.1 ± 2.1		10.1 ± 1.9		10.8 ± 1.6		10.4 ± 1.8		10.5 ± 1.8		<0.01	
Above 2000 Rand	51	78.5	271	92.8	105	91.3	576	96.5	681	95.7	<0.01	0.02
Above 5000 Rand	20	30.8	120	41.1	46	40.0	283	47.4	329	46.2	0.03	
Formal housing	15	22.1	89	30.5	42	36.2	188	31.5	230	32.3		0.05
Food insecurity												
Mother hungry days (mean, SD)	3.7 ± 4.0		4.4 ± 4.5		2.3 ± 3.2		3.6 ± 3.0		3.4 ± 3.0		<0.01	<0.01
Children hungry days (mean, SD)	2.6 ± 4.2		3.5 ± 4.3		1	5 ± 2.8	2.6 ± 3.4		2.4 ± 3.3		<0.01	<0.01
Married/living with partner	43	46.2	208	71.2	76	65.5	442	74	518	72.7	0.02	
3b Adults in household	40	58.8	211	72.3	72	62.1	452	75.7	524	73.5	<0.01	
Maternal risk behaviors												
Depression												
Antenatal	32	49.2	112	42.0	28	25.9	188	34.5	216	33.1	<0.01	0.04
EPDS Score >13	44	64.7	205	70.2	52	44.8	346	58.0	398	55.8	<0.01	<0.01
EPDS Score 218	41	60.3	169	57.9	45	38.8	280	46.9	325	45.6	<0.01	<0.01
Intimate partnerviolence	26	38.2	154	52.7	48	41.4	290	48.6	338	47.4	0.02	
Problematic alcohol use	11	16.2	62	21.3	7	6.0	69	11.6	76	10.7	0.08	<0.01
Protective behaviors												
Exclusive breastfeeding												
For 3 months	1	1.8	14	5.0	23	24.5	125	21.5	148	21.9	<0.01	<0.01
For 6 months	5	8.9	9	3.2	11	11.7	75	12.9	86	12.7		<0.01

	MLH <i>n</i> ^{1/4} 360			MWOH, <i>n</i> ^{1/4} 713			R ^a , <i>n</i> ^{1/4} 1073	HIV only, <i>n</i> ^{1/4} 1073	R only MLH vs. MWOH, <i>n</i> ^{1/4} 184	Non-R only MLH vs. MWOH, <i>n</i> ^{1/4} 889
	Resilience, <i>n</i> ^{1/4} 68, 18.9%	Non-Resilience, <i>n</i> ^{1/4} 292, 81.1%	Total MLH <i>n</i> %	Resilience, <i>n</i> ^{1/4} 116, 16.3%	Non-resilience, <i>n</i> ^{1/4} 597, 83.8%	Total MWOH <i>n</i> %				
Attend preschool Migration	32 94.1	253 87.9	285 88.5	48 88.9	521 89.4	569 89.3	-	-	-	-
Children to rural	25 37.3	117 40.3	142 39.8	34 30.4	205 34.4	239 33.8	-	-	-	-
Children to rural, with mother	18 26.9	46 15.9	64 17.9	19 17.0	104 17.5	123 17.4	-	-	-	-
Children to rural, without mother	10 14.9	84 29.0	94 26.3	20 17.9	123 20.6	143 20.2	0.05	0.02	-	<0.01

The significant results of the x2 analyses are presented by resiliency, resiliency, and nonresiliency stratified by HIV status. EPDS, Edinburgh Postnatal Depression Scale; MLH, mothers living with HIV; MWOH, mothers living without HIV.

^aResiliency.

Table 3.

Sociodemographic factors, maternal risk behaviors, protective behaviors, and migration, grouped by mothers living with HIV or without and mothers with resilient children or not.

	MLH only				MWOH only				P value
	Resilience, n ¼ 68,18.9%	Non-resilience, n ¼ 292,81.1%	Total MLH, n ¼ 360	%	Resilience, n ¼ 68,18.9%	Non-resilience, n ¼ 292,81.1%	Total MWOH, n ¼ 713	%	
Sociodemographic factors									
Maternal age (mean, SD)	27.9 ± 5.5	26.9 ± 5.2	27.1 ± 5.2		25.1 ± 5.5	26.2 ± 5.7	26.0 ± 5.7		0.06
Education (mean, SD)	10.1 ± 2.1	10.1 ± 1.9	10.1 ± 1.9		10.8 ± 1.6	10.4 ± 1.8	10.5 ± 1.8		0.03
Income									
Above 2000 Rand	51	271	322	90.2	105	576	681	95.7	0.01
Above 5000 Rand	20	120	140	39.2	46	283	329	46.2	–
Formal housing	15	89	104	28.9	42	188	230	32.3	–
Food insecurity									
Mother hungry days (mean, SD)	3.7 ± 4.0	4.4 ± 4.5	4.3 ± 4.4		2.3 ± 3.2	3.6 ± 3.9	3.4 ± 3.9		<0.01
Children hungry days (mean, SD)	2.6 ± 4.2	3.5 ± 4.3	3.3 ± 4.3		1.5 ± 2.8	2.6 ± 3.4	2.4 ± 3.3		<0.01
Married/living with partner	43	208	251	69.7	76	442	518	72.7	0.06
3P Adults in household	40	211	251	69.7	72	452	524	73.5	<0.01
Maternal risk behaviors									
Depression									
Antenatal	32	112	144	43.4	28	188	216	33.1	0.08
EPDS Score >13	44	205	249	69.2	52	346	398	55.8	0.01
EPDS 18	41	169	210	58.3	45	280	325	45.6	–
Intimate partner violence	26	154	180	50	48	290	338	47.4	–
Problematic alcohol use	11	62	73	20.3	7	69	76	10.7	0.08
Protective behaviors									
Exclusive breastfeeding									
For 3 months	1	14	15	4.5	23	125	148	21.9	–
For 6 months	5	9	14	4.2	11	75	86	12.7	–
Attend preschool	32	253	285	88.5	48	521	569	89.3	–

	MLH only			MWOH only			Total MWOH, n = 713					
	Resilience, n = 68,18.9%	Non-resilience, n = 292,81.1%	Total MLH, n = 360	Resilience, n = 68,18.9%	Non-resilience, n = 292,81.1%	Total MWOH, n = 713	P value	n	%	P value	n	%
Migration												
Children to rural	25	117	142	34	205	239	-	205	34.4	0.01	239	33.8
Children to rural, with mother	18	46	64	19	104	123	0.03	104	17.5	0.03	123	17.4
Children to rural, without mother	10	84	94	20	123	143	0.01	123	20.6	0.01	143	20.2

The significant results of the x2 analyses are presented by HIV only and MWOH only. EPDS, Edinburgh Postnatal Depression Scale; MLH, mothers living with HIV; MWOH, mothers living without HIV.

Table 4.

Prevalence of resilient children, by neighborhood clusters and maternal HIV serostatus.

Neighborhood cluster	MLH, <i>n</i> ¼ 360						MWOH, <i>n</i> ¼ 713					
	Resilience, <i>n</i> ¼ 68,18.9%		Non-resilience, <i>n</i> ¼ 292,81.1%		Total MLH		Resilience, <i>n</i> ¼ 116,16.3%		Non-Resilience, <i>n</i> ¼ 597,83.3%		Total MWOH	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
1	3	8.6	32	91.4	35	13	24.1	41	75.9	54		
2	4	14.3	24	85.7	28	13	18.3	58	81.7	71		
3	4	17.4	19	82.6	23	5	10.2	44	89.8	49		
4	9	22.5	31	77.5	40	9	12.5	63	87.5	72		
5	12	32.4	25	67.6	37	11	14.9	63	85.1	74		
6	5	20.8	2	79.2	7	11	18.3	49	81.7	60		
7	6	21.4	22	78.6	28	10	14.7	58	85.3	68		
8	3	11.5	23	88.5	26	7	12.7	48	87.3	55		
9	5	15.6	27	84.4	32	4	6.3	59	93.7	63		
10	6	18.2	27	81.8	33	13	21.7	47	78.3	60		
11	2	11.1	16	14.6	18	5	14.3	30	85.7	35		
12	9	25.0	27	75.0	36	15	28.9	37	71.1	52		

MLH, mothers living with HIV; MWOH, mothers living without HIV.

^aResiliency.

Table 5.

Sociodemographic factors, maternal risk behaviors, protective behaviors, and migration, grouped by resilient and non-resilient children and their mothers in the neighborhoods with a high prevalence (27%) or low prevalence (11%).

	Resilient children, n ¼ 52						Non-resilient children, n ¼ 284					
	HP cluster, n ¼ 24		LP cluster, n ¼ 24		Total resilience		HP cluster, n ¼ 24		LP cluster, n ¼ 24		Total non resilience	
	n	%	n	%	n	%	n	%	n	%	n	%
Sociodemographic factors												
Maternal age (mean, SD)	26.3 ± 6.54		25.8 ± 5.46		26.0 ± 5.93		27.0 ± 5.04		25.4 ± 5.01		25.8 ± 5.04	
Education (mean, SD)	10.3 ± 1.79		10.1 ± 1.77		10.2 ± 1.76		10.3 ± 1.82		10.0 ± 1.88		10.1 ± 1.87	
Income												
Above 2000 Rand	19	82.6	23	85.2	42	84.0	62	96.9	209	95.0	271	95.4
Above 5000 Rand	10	43.5	15	55.6	25	50.0	26	40.6	85	38.6	111	39.1
Formal housing	15	62.5	4	14.3	19	36.5	33	51.6	35	15.9	68	23.9
Food insecurity												
Mother hungry days(mean, SD)	1.71 ± 2.39		3.36 ± 4.73		2.6 ± 3.89		4.30 ± 4.55		3.95 ± 3.89		4.0 ± 4.02	
Children hungry days(mean, SD)	1.13 ± 2.35		2.71 ± 5.46		2.0 ± 4.3		3.5 ± 3.95		2.96 ± 3.54		3.10 ± 3.6	
Married/living with partner	17	70.8	18	64.3	35	67.3	47	73.4	173	78.6	220	77.5
3P Adults in household	18	75.0	19	67.9	37	71.2	53	82.8	154	70.0	207	72.9
Maternal risk behaviors												
HIV positive status	9	37.5	12	42.9	21	40.4	27	42.2	69	31.4	96	33.8
Depression	10	41.7	20	71.4	30	57.7	43	67.2	138	62.7	181	63.7
EPDS Score 213	8	33.3	18	64.3	26	50.0	33	51.6	105	47.7	138	48.6
EPDSScore218	10	41.7	13	46.4	23	44.2	36	56.3	110	50.0	146	51.4
Intimate partner violence	4	16.2	3	10.7	7	13.5	8	12.5	29	13.2	37	13.0
Problematic alcohol use												
Protective behaviors												
Exclusively breastfeeding	3	14.3	5	20.8	8	17.8	11	17.2	25	11.7	36	13.0
Up to 3 months												

	Resilient children, <i>n</i> = 52				Non-resilient children, <i>n</i> = 284				R	Prevalence	HP cluster only	LP cluster only		
	HP cluster, <i>n</i> = 24		Total resilience		HP cluster, <i>n</i> = 24		LP cluster, <i>n</i> = 24						Total non resilience	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%					<i>n</i>	%
Up to 6 months	1	4.8	1	4.2	2	4.4	6	9.4	22	10.3	28	10.1	-	-
Attend preschool	14	93.3	15	83.3	29	87.9	52	81.3	190	88.0	242	86.4	-	-
Migration														
Children to rural	13	54.2	10	35.7	23	44.2	20	31.3	83	37.7	103	36.3	-	-
Children to rural, with mother	9	37.5	5	17.9	14	26.9	11	17.2	44	20.0	55	19.4	-	0.04

The significant results of χ^2 analyses are presented by resiliency, prevalence, and prevalence by resiliency, EPDS, Edinburgh Postnatal Depression Scale; HP, high prevalence; LP, low prevalence.