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Empirical Research

# "We Don't Have Things for Counting": An Exploration of Early Numeracy Skills and Home Learning Experiences of Children Growing up in Poverty in South Africa

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**Supplementary Materials:** Materials [see Index of Supplementary Materials]

## Abstract

A child's home environment has been shown to be related to the development of early numeracy skills in some countries. However, significant relationships between home learning environment and math achievement have not consistently been found, and likely vary across different cultural and socio-political contexts. Here we explored the home environment and early numeracy skills of 243 children (3-5 years), who were not attending preschool programmes in very low-income settings in Cape Town, South Africa. Caregivers completed a questionnaire including information regarding experiences of children in the home; children completed a number identification task, a counting task and the Give-N task. The amount of resources in the home learning environment (e.g. the number of books and toys), frequency of home learning activities caregivers did with their children, and caregiver levels of education and income were not associated with number knowledge. While the home learning environment has been shown to be important for developing early numeracy skills in previous research, this study suggests that factors other than the home learning environment may also be important targets to foster numeracy skills and school readiness in low-income settings in South Africa.

## Keywords

home environment, early numeracy, low-income settings, South Africa

The preschool years are a critical time to maximize early childhood development and set children up for success as they navigate their educational pathway. For some time, there has been concern regarding the quality of school programmes and poor schooling outcomes in low- and middle-income countries (LMICs) such as South Africa (Biersteker et al., 2016). Implementation and participation in early learning programs have been effective in improving early learning outcomes for young children living in South Africa, but it is often the case that caregivers do not have the means to access these programmes for their children (Dawes et al., 2020). The main barrier to accessing programmes is the cost because they are not subsidised by public funds, and therefore children from low-income settings are the least likely to be able to access early learning programmes, with access gaps persisting into formal schooling (Hall et al., 2019). Researchers have

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therefore turned towards looking at home environments as a potential means for academic development. Research in a wide range of socioeconomic settings has shown that the home learning environment plays an important role in the development of academic skills, including early numeracy skills (Anders et al., 2012; Kleemans et al., 2012; Segers et al., 2015). Early numeracy skills are important as young children's development of these skills has been shown to correlate longitudinally with later school-age mathematical and learning performance (Aunio et al., 2015; LeFevre et al., 2009; Raghubar & Barnes, 2017). Consequently, ensuring that all youth achieve numeracy, in addition to literacy, is one of the targets of the United Nations' Sustainable Development Goal 4 (United Nations, 2016) and many governmental and philanthropic initiatives (Evans & Hares, 2021). Previous research found that only 38% of children who completed grade 6 in South Africa acquired basic numeracy skills (Spaull & Taylor, 2015). Concerns about children's math learning start early: only 16% of students in grade 3 meet the curriculum standards (Spaull & Kotze, 2015), and there is large variation in children's numeracy knowledge when they enter formal schooling (Aunio et al., 2016). Children's numeracy skills are related to their home languages and family income levels (Aunio et al., 2016), suggesting inequality of early education opportunities. Here we investigated numeracy skills prior to formal school entry, in children growing up in poverty who were not enrolled in early childhood education. To our knowledge, no previous research has explored numeracy skills in South African children who have not yet started formal school. We aimed to identify barriers and potential for developing foundational numeracy skills in these communities.

## Early Academic Outcomes in LMICs

It is estimated that over 250 million children under the age of 5 years in LMICs are exposed to multiple risks for not reaching their developmental potential, including poverty (Black et al., 2017; Brown, Mistry, & Yip, 2019; Grantham-McGregor et al., 2007). Distressingly, it is common for young children in South Africa to grow up in extremely impoverished and harsh environments where they are exposed to abuse, violence, and neglect (Hills et al., 2016; Martin et al., 2013). There has been considerable research over the years showing those who experience childhood adversity and grow up in poverty tend to score lower on a wide variety of cognitive tasks (Duncan et al., 2017; Ursache & Noble, 2016). However, many children show resilience in the face of adversity (du Toit et al., 2021); for instance, children from low-income backgrounds in South Africa were found to perform higher than children in HICs countries on executive function tasks (Howard et al., 2020), suggesting untapped cognitive potential that could be further fostered by understanding optimal early learning environments. More research is therefore needed to better understand the complex relationships between the home environment and cognitive development in the early years across a variety of countries and contexts.

## Home Learning Environment and LMICs

Opportunities for learning in young children must first be created in the home, especially if children do not attend preschool (Rao et al., 2014). Unfortunately, in LMICs such as South Africa, many parents and caregivers may have never attended school or attended a poor quality school and, therefore have low levels of literacy and numeracy (Modisaotsile, 2012). Often parents from low socioeconomic backgrounds are unaware of the importance and need for stimulation to promote child development in the early years (Guldan et al., 1993; UNICEF, 2001). In South Africa it has been found that many parents and caregivers have limited access to home learning resources, such as books and games, very limited time to engage in home learning activities with their children and never engage in learning activities that require resources, such as reading books (Dawes et al., 2020; Draper et al., 2023[1]). Notably, the measure of the home learning environment developed by Dawes and colleagues (2020) is different from measures used to investigate more specifically the home *mathematics* environment in previous research. The majority of research linking the home environment and math achievement has been carried out in high-income countries (HICs) (e.g., Campbell & Verna, 2007; Melhuish et al., 2008) and has found relationships between math activities done at home and academic skills, such as arithmetic (e.g. LeFevre et al., 2009).

1) The quote in the title of this paper comes from an interview described here.



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### The Home Learning Environment and Early Mathematics Achievement

Results of these studies investigating relationships between parent engagement in numeracy activities and their children's math achievement are inconsistent, likely due to cross-cultural differences in education systems and parental attitudes (Blevins-Knabe et al., 2000; Hornburg et al., 2021; Kleemans et al., 2012; LeFevre et al., 2009; Mutaf-Yıldız et al., 2020; Pan et al., 2006). A study involving Chilean families showed that parent-supported numeracy activities can have a significant impact in promoting development of early numeracy skills (Susperreguy et al., 2020). However, another study with Mexican families found relationships between home numeracy activities and children's math skills in families from higher SES backgrounds, but not in families from relatively lower SES backgrounds (Susperreguy et al., 2021). Accordingly, researchers in the field have called for more international and interdisciplinary collaboration to better capture the nuances of the home math environment (Hornburg et al., 2021).

### Current Study

This study aimed to explore which aspects of a child's environment might relate to numeracy skill levels of young children in very low-income settings in South Africa. Specifically, this study involved an exploratory analysis that focused on family income, caregiver education, the home learning environment (resources in the home, activities done with children and time spent with children) of preschool-aged children not enrolled in early education.

## Method

### Participants and Recruitment

Participants included preschool-aged children who were not attending preschool or early childhood development (ECD) centres in low-income areas of Cape Town, South Africa. The current study forms part of a short-term longitudinal study that aimed to understand the barriers to and potential of early childhood education in low-income South Africa. In year one of the study (2020) children 3-5 years old, along with their primary adult caregiver (>18 years old) were recruited. Given that many children in low-income settings in South Africa are not raised by a biological parent, the term 'caregiver' is used to include other adult caregivers, e.g., grandmothers and aunts. A total sample of 243 children (126 female, 117 male), mean age 4 years, 8 months (range 2 years, 9 months – 5 years, 10 months) and their caregivers were recruited through a community-based organisation that works with approximately 8000 families in low-income settings across the Western Cape province. Recruitment was facilitated through organisation's home visitors, who informed the caregivers of the research study. Due to COVID-19 restrictions in place at the time, final recruitment by study researchers took place telephonically. Contact numbers of interested caregivers were passed to the research assistants, who provided the potential participants with information about the study, answered any questions, and invited caregivers to participate. When initial face-to-face contact was made by the home visitors, signed consent forms were collected from participants. The procedures for this study were approved in advance by the Human Research Ethics Committee (Medical) of the University of Witwatersrand.

### Study Sites

Participants were recruited from four low-income communities within the Cape Town Metropolitan area. Two of the communities are classified as an urban township ('Setting 1') and are made up of mostly informal housing (see Figure 1). Informal housing refers to structures, often shacks, that are typically unauthorized and have been established on land that has not been designated for residential use. Families living in informal housing may not have consistent access to city services, including water and electricity (City of Cape Town, 2023). Overcrowding is an issue in these communities with population densities of 10,120.31 per $km^2$ and 16,957.67 per $km^2$. Other challenges include high rates of unemployment, food insecurity, alcohol abuse, crime and human immunodeficiency virus/acquired immune deficiency syndrome. The other two communities make up 'Setting 2' and are made up of both formal and informal housing. The population density varies within the suburbs from which participants were recruited (between 4255.94 per $km^2$ and 16553.99 per $km^2$). Gang activity and drug abuse are major challenges in this community, in addition to high



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rates of unemployment, crime, and food insecurity. For more information about the settings and participating families please refer to a qualitative study in the same settings (Draper et al., 2023).

**Figure 1**

*Image of Informal Housing in Cape Town*

## Materials

### Caregiver Questionnaire

The caregiver questionnaire asked questions about demographic details, socioeconomic status, and the home learning environment (see Supplementary Material). Selected items from the National Income Dynamics Survey that is used across South Africa was included to assess household socioeconomic status, including household income and a household asset score (http://www.nids.uct.ac.za). The caregiver questionnaire also assessed child exposure to community violence, parent and family adjustment (using a published measure, Sanders et al., 2014), and impacts of COVID-19, which are not reported in this paper.

Previous research on math outcomes and the home learning environment in HICs has explored the home numeracy environment specifically by asking about games and books they have in their homes that have mathematical content (e.g. Skwarchuk et al., 2014). However, given that previous research found that many families in South Africa have very limited resources in the home, and may not have any books at all (Dawes et al., 2020), the Home Learning Environment (HLE) scale, adapted for use in South Africa (Dawes et al., 2020), was used to evaluate factors within the home environment that influence learning. This survey draws on the UNICEF Multiple Cluster Index Survey for children under 5 years with regards to resources that may be available in the home of South African children (www.mics.unicef.org/tools). The HLE scale included the a) frequency of home learning activities, b) time spent with the child, and c) books and toys in the home.

a. For the home learning activities (reading, playing, singing, telling the name of things, taking the child outside the home, counting things and drawing or painting things), caregivers were asked to report whether they, or another household member, engaged in these activities with their children *never* (coded as 0), *sometimes* (coded as 1) or *many times* (coded as 2) in the past week. Scores for each activity were combined to form a total score, with a higher score indicating a higher frequency of home learning activities.
b. For time spent with the child, caregivers were asked about the time they have to play and talk to their child on weekdays and weekends. The options were *very little time* (<1 hour, coded as 1), *some time* (about 2 hours, coded as 2), and *lots of time* (more than 2 hours, coded as 3). The score for weekdays and weekend days were combined to form a total score, with a higher score indicating more time spent with their child.
c. Caregivers were also asked if children had books, homemade toys, toys from a shop, or used household objects (such as bowls, pots or bottle tops) or objects found outside (such as sticks or leaves) as toys. Caregivers responded with either *yes* (coded as 1) or *no* (coded as 0). If caregivers responded *yes* to having books, they were asked to give



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the number of books they had in the home (*N* books). The *N* number of books was combined with the responses for having homemade toys, toys from a shop and household objects to form a total score for resources in the home.

### Early Numeracy Measures

**Give-N** — The Give-*N* task was used to measure children's cardinality knowledge (Wynn, 1990). The experimenter asked the child to give a toy sets of different numbers of objects. Soft toy dogs were used by experimenters and children were asked to give sticks to the dog. Children were asked to give up to eight objects, and the number asked for was adjusted based on their response. Children were considered an *N*-knower if they correctly gave that number of items twice, and incorrectly gave the next highest number twice (e.g., a child who correctly gave two blocks twice when asked for two but failed to give three blocks correctly twice when asked for three, would be considered a two-knower). Children who can correctly give at least five items are considered CP-knowers. It is thought that once children have learned five, they can then generalize to larger numbers and understand the cardinal principle.

**Number Identification and Counting** — The number identification and number counting tasks were taken from the Herbst Early Childhood Developmental Criteria test (ECDC; Herbst & Huysamen, 2000). These tasks were developed specifically for child-centered testing in the South African context to assess cognitive developmental skills that underlie school readiness in 3- to 6-year-old children. A numeral identification task was used to determine if children were able to assign the correct verbal labels to numerals. The grid consisted of three rows of 10 digits in random order. For this task children were presented with a number grid. The tester pointed to a specific number and asked the child to name it, starting with 1, then 3, then numbers at random. Points were awarded for every number correctly identified with a maximum of 6 numbers.

In the counting task, children were asked to count sticks. Twenty sticks were laid down in front of the child. The child was then asked whether they can count and then asked to count all the sticks, while at the same time moving them one by one. This was first demonstrated to the child by counting "One, two…" and moving the first two sticks away from the others. The sticks were then put back into the starting position and the child was asked to do the same with all of the sticks in front of them. If the child could not do this correctly, they were asked to count without handling the sticks. The maximum score was six as there were six items. For some items, children were asked count, and for others, to accurately show the correct number of sticks.

## Procedure

All testing was conducted by three trained research assistants who could speak the home language of the participants (IsiXhosa or English). Many families spoke Afrikaans at home, but most of these families spoke English as well as Afrikaans and completed the sessions in English. When families did not understand English, the home visitors helped translate to Afrikaans. Due to COVID-19 restrictions and the fact that some of the areas from which participants were recruited from posed a safety risk to the research assistants, testing took place in various ways. Most participating families completed the caregiver questionnaires in person on the same day as their children completed the tasks. During South Africa's hard lockdown, caregiver questionnaires were administered telephonically to 30 participants. As the numeracy tests had to be done in person, these only took place once restrictions had eased and it was safe to do so. For these families, the time between caregiver questionnaire and child testing ranged from 5-95 days, with an average of 50 days. For two of the areas, child testing (and caregiver questionnaires that had not been administered over the phone) took place at the household of the participants at a time that was suitable for the participant. For the other two areas that posed a safety risk for the research assistants, a central venue was organised and participants (caregiver and child) were given transport money to come to the testing venue. All tests were explained to caregivers and children so that they knew what was expected of them. Child participants completed numeracy tasks as well as additional assessments that were included as part of the larger study. If there was more than one child in the household that qualified to participate in the study, a separate questionnaire was administered for each child. The children participated in the tasks individually with instruction from the home visitor. The researchers did not give the children feedback on the accuracy of their responses and caregivers were asked not to give their children feedback. Caregivers received grocery vouchers



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(to the value of ~18 USD) for completing the questionnaire and again for bringing their child to testing. Children received stickers for their participation.

# Results

## Family Demographics

Family demographic details are presented in Table 1. Participants were recruited from very low-income areas and 95.4% of caregivers reported their monthly household income was below ZAR6000 (~330 USD), with most (67.1%) reporting monthly income between ZAR750-ZAR3300 (~47-207 USD). Of the participating caregivers, 25.9% had completed high school and 15.6% had completed post-school training.

**Table 1**

*Sample Demographic Details*

| Demographic details | Total (*N* = 243) | Setting 1 (*N* = 119) | Setting 2 (*N* = 124) |
|---|---|---|---|
| **Caregiver age (*M* ± *SD*)** | 37.0 ± 11.2 | 35.7 ± 9.3 | 38.2 ± 12.6 |
| **Relationship to the child (%)** | | | |
| Mother | 72.0 | 78.2 | 66.1 |
| Father | 4.5 | 2.5 | 6.5 |
| Grandmother | 16.9 | 12.6 | 21.0 |
| Grandfather | 0.0 | 0.0 | 0.0 |
| Aunt | 4.9 | 5.8 | 4.0 |
| Uncle | 0.0 | 0.0 | 0.0 |
| Other | 1.6 | 0.8 | 2.4 |
| **Child age on date of testing (*M* ± *SD*)** | 4.75 ± 0.58 | 4.66 ± 0.61 | 4.83 ± 0.53 |
| **Child Sex (% female)** | 51.9 | 50.4 | 53.0 |
| **Marital status (%)** | | | |
| Married | 32.5 | 30.4 | 34.7 |
| Living with partner | 10.7 | 13.5 | 8.1 |
| Widow | 5.3 | 5.9 | 4.9 |
| Divorced | 4.1 | 2.5 | 5.7 |
| Never married | 47.3 | 47.9 | 46.8 |
| **Household composition (*M* ± *SD*)** | | | |
| Number of children | 3.00 ± 1.53 | 2.66 ± 1.29 | 3.34 ± 1.67 |
| Number of adults | 2.86 ± 1.45 | 2.49 ± 1.18 | 3.29 ± 1.59 |
| **Household income (%)** | | | |
| R750 or less | 7.1 | 2.6 | 11.3 |
| R750-R1500 | 30.8 | 31.0 | 30.7 |
| R1500-R3300 | 36.3 | 34.5 | 37.9 |
| R3300-R6000 | 19.6 | 23.3 | 16.1 |
| R6000-R11000 | 4.2 | 6.0 | 2.4 |
| R11000-R27000 | 0.0 | 0.0 | 0.0 |
| R27000 or more | 0.4 | 0.9 | 0.0 |



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| Demographic details | Total (*N* = 243) | Setting 1 (*N* = 119) | Setting 2 (*N* = 124) |
|---|---|---|---|
| **Household asset score (*M* ± *SD*)** | 7.81 ± 2.91 | 8.24 ± 2.70 | 7.39 ± 3.06 |
| **Home Language (%)** | | | |
| isiXhosa | 47.3 | 95.8 | 0.8 |
| Afrikaans | 44.0 | 0.8 | 85.5 |
| English | 28.0 | 1.7 | 53.2 |
| **Caregiver education level (%)** | | | |
| Less than HS diploma | 74.1 | 62.2 | 85.5 |
| HS diploma | 25.9 | 37.8 | 14.5 |
| **Post-school training** | 15.6 | 20.2 | 11.3 |
| Certificate | 12.8 | 15.1 | 10.5 |
| Diploma | 0.4 | 0.8 | 0.0 |
| Degree | 2.1 | 3.4 | 0.8 |

## Home Learning Environment

Regarding time spent with the child doing the activities mentioned above, Figure 2a and 2b display the reported frequency of each household activity in the past week. Of note, 34.4% of caregivers from Setting 1, and 30.6% of caregivers from Setting 2 reported never reading books to their children, although it is important to put this note into context, as a significant proportion of parents across settings did not have books or had very few (see below).

**Figure 2a**

*Frequency of Home Learning Activities: Home Learning Activities With Children in the Past Week in Setting 1*

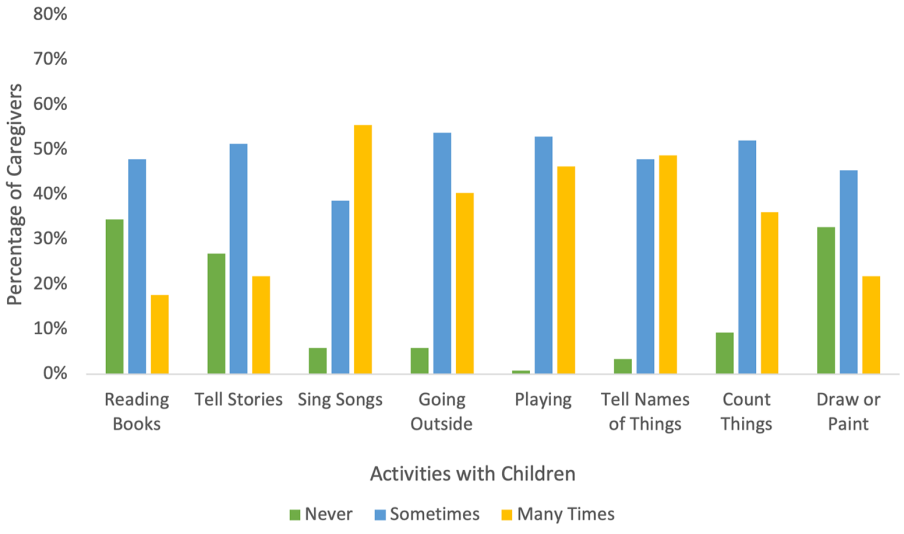




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**Figure 2b**

*Frequency of Home Learning Activities: Home Learning Activities With Children in the Past Week in Setting 2*

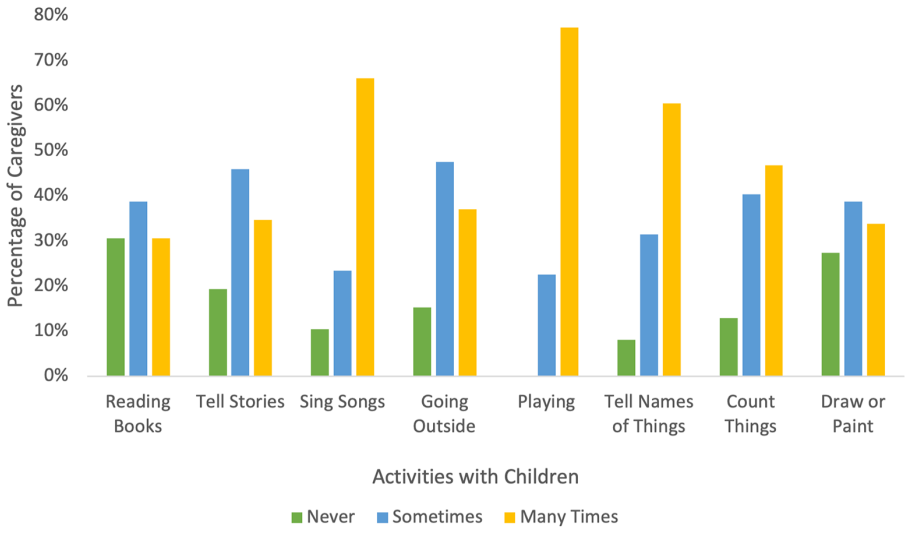


Figure 3 and 3b display the reported amount of time caregivers spent with their children on the weekdays and on the weekend. The variables were not normally distributed so we ran Mann-Whitney U tests to investigate whether the home learning environment measures differed across settings. As shown in Table 2, caregivers from Setting 2 had a higher frequency of home learning activities ($p$ = .003), and spent more time with their child ($p$ = .015). Due to these differences, HLE data are therefore reported separated by setting.

**Table 2**

*Descriptive Statistics of Home Learning Environment Measures*

| Home Learning Environment Measure | Setting 1 *M* (*SD*) | Setting 2 *M* (*SD*) | *p* |
|---|---|---|---|
| Frequency of home learning activities | 9.66 (2.74) | 10.63 (3.18) | .003 |
| Time spent with child total | 3.74 (1.70) | 4.28 (1.75) | .015 |

**Figure 3a**

*Time Spent With Child: Amount of Time Spent With Child in Setting 1*

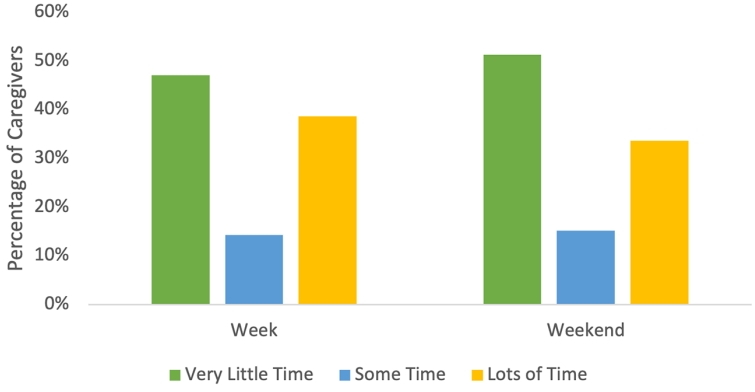




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**Figure 3b**

*Time Spent With Child: Amount of Time Spent With Child in Setting 2*

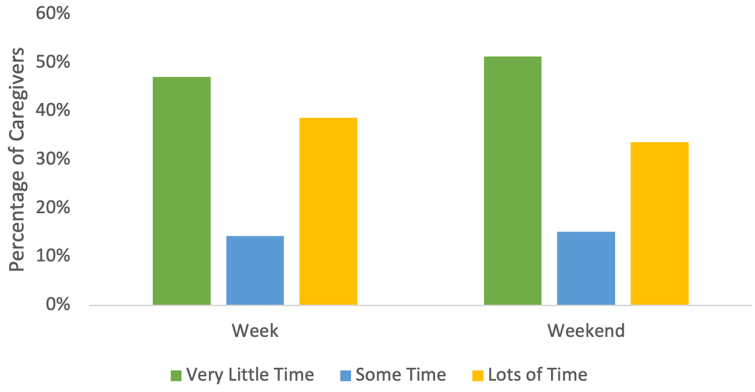
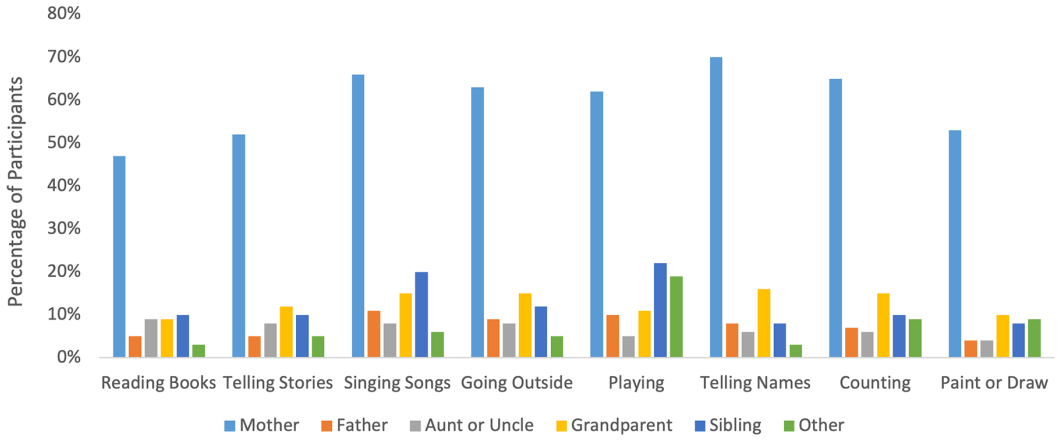



Figure 4 displays the people in the child's life who participated in learning activities with the child. Most often it was the mother who was reported to participate in these activities, but siblings were often reported to play or sing songs with the child. However, caregivers reported cousins, friends, and members of community-based organisations as others who were also participating in activities with children.

**Figure 4**

*People Reported to Participate in Home Learning Activities With the Child*




Common household objects children were reported to play with include bowls, pots, utensils, bottles/ bottle tops, sticks and stones. Of those who reported having homemade toys, many reported making cars out of cardboard and dolls out of old clothing or material. In Setting 1, 60.5% of caregivers reported that they have some books in the home, as an educational resource for their children, and 75.8% of caregivers in Setting 2 reported having some books. Of the caregivers who reported having some books, the median number of books was 2 ($SD$ = 1.6) for Setting 1, and 3 for Setting 2 ($SD$ = 3).

## Numeracy Scores

Some numeracy data were missing because the child refused to do the task or got distracted by their environment and lost focus. Data were missing from 43 children for number identification, 45 children for counting, and 45 for



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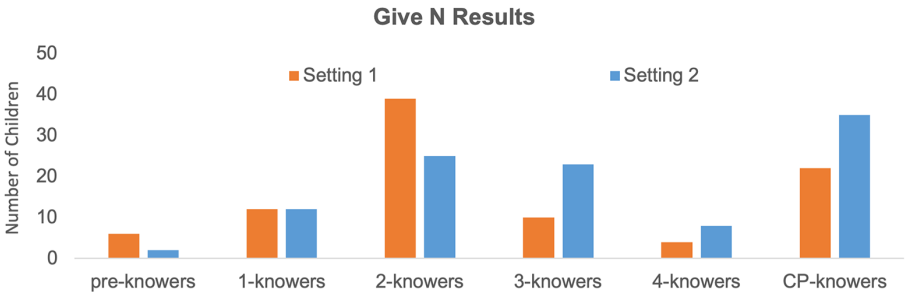
Give-*N*. One child was too young to be included in the study. Independent samples *t*-tests revealed that there were no significant differences in numeracy scores across settings, so data were collapsed across settings for these analyses. Children's scores on the number identification task ranged from 0-6 ($M$ = 1.51, $SD$ = 1.71) and scores on the counting task ranged from 0-6 ($M$ = 2.57, $SD$ = 2.06). Many children struggled with the numeracy tasks, and thirty-seven percent of participating children did not identify any numerals. Most children (71.2%) were not cardinal principle-knowers (see Figure 5).

**Figure 5**

*Give-N Knower Level Distributions*




Spearman's rho correlations between home environment factors and counting and number identification are reported in Table 3. Numeracy scores were positively correlated with each other and with children's age, but there were no significant correlations between numeracy scores and the home environment or household asset variables. Frequency of home learning activities was significantly, but weakly, positively correlated with the household assets score, which is an indicator of family socioeconomic status.

**Table 3**

*Spearman's Correlations Between Numeracy Measures and Home Environment Variables*

| Variable name | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. Age | – | | | | |
| 2. Counting Sticks | .298* | – | | | |
| 3. Number identification | .302* | .442* | – | | |
| 4. Give N | .317* | .646* | .455* | – | |
| 5. Household assets score | -.040 | .152 | .150 | -.017 | – |
| 6. Frequency of home learning activities | .090 | .005 | .088 | .084 | .169* |

Given that previous research has looked at relationships between maths learning activities in the home specifically and children's numeracy outcomes, we investigated whether the children of caregivers who reported counting more frequently had higher scores on the counting sticks task, because it most closely mirrored the activity carried out with caregivers. We ran a Welch's one-way ANOVA because the groups were uneven and the assumption of normality was violated. There was no significant difference in counting scores between the three groups of children whose parents reported counting with them never, sometimes, or many times, $F(2, 53.1) = 0.09$, $p = .91$ (see Figure 6). We note, however, that the frequency of counting activities parents could report on were not very granular, it does not give insight into the nature of the counting activities with the child (e.g., for how long, in what context, to what level of complexity and of engagement by the child), and a smaller number of parents reported never counting with their child compared to counting many times, so null findings may depend on measurement constraints and uneven numbers in each category of responses. Previous research has found relationships between children's numeracy skills and more formal learning



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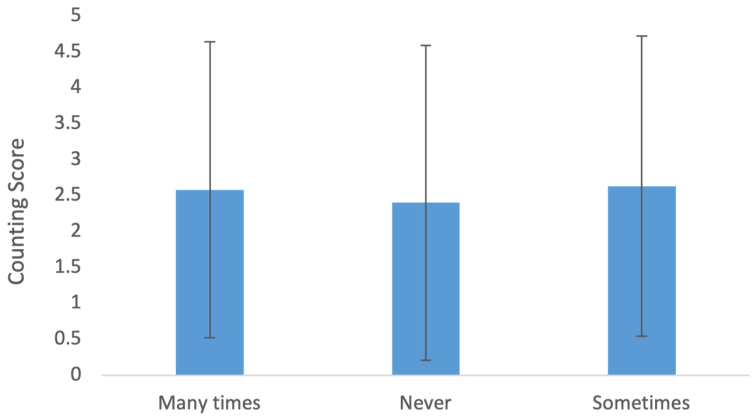
activities. We therefore also tested whether how often caregivers reported reading books with their children was associated with children's counting sticks scores. There was no significant difference in counting scores between the three groups of children whose parents reported reading with them never, sometimes, or many times, $F(2, 120) = 0.289$, $p = .75$.

**Figure 6**

*Mean Counting Score*




## Discussion

The aim of this study was to explore the home environment and early numeracy skills of preschool-aged children living in poverty in Cape Town, South Africa. Most caregivers reported either themselves, or another individual, frequently participating in at-home learning activities with their children, although mothers were the ones engaging in activities most frequently. Many caregivers reported that siblings, cousins and grandparents were the ones engaging in learning activities with their children, rather than parents. It is encouraging that children appeared to be engaging with multiple individuals, particularly if primary caregivers had limited time. However, we did not find relationships between home learning environment indices and children's numeracy skills. This is consistent with other studies that did not observe a relationship between home environment, and numeracy and mathematical skills of Filipino, African American, Chinese, Mexican and Dominican children in low-middle-income communities (Cheung et al., 2018; Leyva et al., 2019; Susperreguy et al., 2021), suggesting that factors other than the home learning environment may also be important targets to foster certain numeracy skills in these settings. Complementing quantitative HLE scales with qualitative data may highlight these additional factors. Alternatively, it is possible that the HLE plays a role, but its contributions are not well captured by the current HLE scales: for example, frequency of activities may be less important than the nature of activities and depth of experiences within these activities. At a minimum the current findings suggest that simple quantity of activities does not correlate with outcomes, so perhaps a future focus could be to focus on quality, rather than quantities of activities. In particular, the type of mathematical language used by caregivers should be considered in future research as an indicator of home learning quality (e.g. Levine et al., 2010; Leyva et al., 2017). For example, in the United States, children in higher SES environments tend to have more frequent opportunities to hear more school-aligned math language at home (Hanner et al., 2019). The amount of mathematical language in caregiver speech has been shown to be associated with children's mathematical abilities in families from diverse ethnic and socioeconomic backgrounds (Ramani et al., 2015). Again, a greater qualitative focus in populations outside of families in high income countries may shed light on potential HLE factors that operate in these different contexts. Adopting a truly international, interdisciplinary approach to studying the home mathematics environment requires including more researchers from countries outside of North America and Europe (Hornburg et al., 2021) and considering the diverse home lives of families around the world. The majority of children globally are developing within inequitable



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socioeconomic contexts and these inequities must be considered in developmental science theories and methods (Brown, Mistry, & Yip, 2019).

Many caregivers in the study did not have much time or many resources to engage in early learning activities with their children. Most participants reported a monthly income between ZAR750-R3300 (~47-207 USD), and many caregivers had not completed high school, making it challenging to provide quality learning opportunities for their children. A high percentage of caregivers reported never drawing or painting and never reading with children, which was also reported in Dawes et al. (2020), with 32% of participants reporting never reading to their children. Given that these participants reported having a very low income, it is possible that there were caregivers never engaging in these activities with their children because these activities required resources they did not have. Similar to Dawes et al. (2020), the majority of caregivers reported having toys in the home for children to play with including books, toys from a shop and household objects. However, the exact number of books and toys that were reported to be present in homes was often quite low and many participants could easily count the number of toys and books they had. For example, many reported only having 1-5 books. This is quite different from high-income households where it would be difficult to list all the books and toys in the home.

Previous research on mathematics learning in South Africa has highlighted the inadequate acquisition of basic skills and the resulting consequence of not performing at grade level (Spaull & Kotze, 2015). Moreover, differences in early numeracy skill levels have been found between low- and middle-income children and high-income children starting school in South Africa, with low- and middle-income children performing at lower levels than high-income children (Aunio et al., 2016). Children who spoke English at home, which is often the language of instruction in South Africa, were also found to perform better on an early numeracy test than children who spoke a different language at home (Aunio et al., 2016). Thus, prior research has found that differences in the home environment may influence children's number knowledge in the first years of formal school. We did not find SES differences in the current study, likely because the sample was fairly homogeneous with most families having very low incomes.

Children included in this study were those not attending preschool or ECD centres and thus are the most at risk of not developing early numeracy skills in preparation for school. For instance, most children in this sample (71.2%) had not yet learned the concept of cardinality. Previous research in HICs has found that the age at which children learn the cardinal principle is associated with their later math achievement in school, suggesting that this is an important early numeracy skill (Geary et al., 2018). However, results from a previous study in South Africa demonstrated that the majority (85.7%) of first graders still had not acquired the concept of cardinality (Fritz et al., 2020). There was a clear gap between the first grade curriculum expectations, which require a fully developed concept of cardinality, and the learners' number knowledge at school entry (Fritz et al., 2020). This suggests that early instruction needs to be improved to ensure all children learn crucial foundational numerical skills.

In terms of limitations of this study, here we focused more broadly on the home learning environment, and we did not focus specifically on numeracy activities such as direct instruction (such as naming or writing numbers) or numeracy-related activities (such as card games or cooking) in the home or parental attitudes towards math related activities. These more numeracy-specific activities have been shown to correlate with mathematical skills (LeFevre et al., 2009; Susperreguy et al., 2020) and therefore will need to be further investigated in low-income South African settings, especially with regards to quality, beyond quantity, of these interactions. Also, the caregiver questionnaire may not have been sensitive enough to pick up subtle differences within children, caregiver and household that contribute either positively or negatively to their numeracy skills. Future work should explore how family caregiving dynamics may influence the home learning environment in low-income South African settings in general, and home numeracy more specifically. A strength of this study is that it took an exploratory approach to better understand how the home environment relates to early numeracy skills. Given other data collected on the impact of COVID-19 on routines for the broader study, it is unlikely that findings from this study were affected by COVID-19 restrictions.

In these resource-challenged settings, when considering how to promote numeracy (and other early learning) skills with children who have limited early learning opportunities, it is important to leverage existing low-cost activities that are compatible or consistent with what those caregivers are already engaging in with their children but have been optimised for conferring developmental benefit. This can help to reduce the burden on these caregivers, who themselves have had limited educational opportunities, and can empower them with ways in which to further stimulate their



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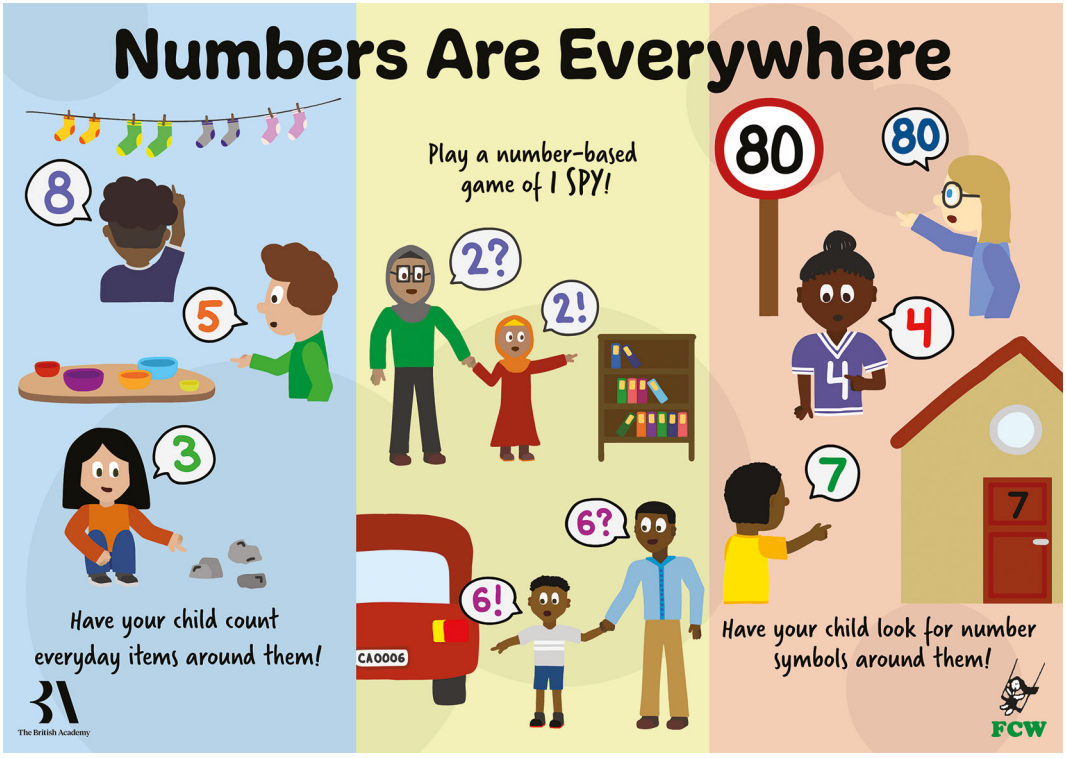
child's development. Indeed, according to the notes from the field researchers, many participating caregivers said they wanted to help their children with counting and numbers after observing their performance on the numeracy tasks but lacked time or resources. For this reason, and following from these results, a resource was developed for caregivers to promote numeracy skills with their child: 'Numbers are everywhere' (Figure 7). This resource was generated after completion of initial data collection, as a potential means to reach caregivers at a greater scale. It was shared with the community-based organisation, the partner on the project, in order to positively contribute to the collaborative relationship, and further raise awareness about the importance of early numeracy activities for the children they reach. Future research should explore caregiver engagement with this and other resources to support early learning at home.

**Figure 7**

*Infographic Shared With Community Partner*




## Conclusion

Based on these findings, a child's home environment in this setting is often one where caregivers may benefit from reminding of the importance of basic numeracy skills for young children, perhaps more so because caregivers simply do not have the means to provide resources for children to develop early numeracy skills. Encouragingly, there are many learning activities that caregivers do participate in with children that do not require or require limited resources such as singing songs, going outside or counting. Although our preliminary analyses suggest that the frequency of these activities may not have impacted children's numeracy skills directly, there still may be other positive outcomes as a result. Further educating parents on low-cost activities they can do at home to promote early numeracy, and how to then extend these to maximise numeracy benefits within their limited available time, could be highly beneficial.



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## Supplementary Materials

The Supplementary Materials contain the home learning environment survey items (for access see Index of Supplementary Materials below).

### Index of Supplementary Materials

Merkley, R., Sernoskie, E., Cook, C. J., Howard, S. J., Makaula, H., Mshudulu, M., Tshetu, N., Draper, C. E., & Scerif, G. (2023). *Supplementary materials to "'We don't have things for counting': An exploration of early numeracy skills and home learning experiences of children growing up in poverty in South Africa"* [Survey items]. PsychOpen GOLD. https://doi.org/10.23668/psycharchives.12955

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