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Improving Child Development and Parenting Skills by Integrating an Early Child Development Intervention into Primary Health Care in Rural Lesotho

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TITLE

Improving Child Development and Parenting Skills by Integrating an Early Child Development Intervention into Primary Health Care in Rural Lesotho

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ABSTRACT

Objectives: This study evaluated a novel early child development (ECD) program integrated it into the primary healthcare system.
Setting: The intervention was implemented in a rural district of Lesotho from 2017-2018.
Participants: It targeted primary caregivers during routine post-natal care visits and through village health worker home visits.
Intervention: The hybrid care delivery model was adapted from a successful program in Lima, Peru and focused on parent coaching for knowledge about child development, practicing contingent interaction with the child, parent social support and encouragement.
Primary and secondary outcomes measures: We compared developmental outcomes and caregiving practices in a cohort of 130 caregiver-infant (ages 7-11 months-old) dyads who received the ECD intervention, to a control group that did not receive the intervention (n=125) using a case-control study design. Developmental outcomes were evaluated using the Extended Ages and Stages Questionnaire (EASQ), and caregiving practices using two measure sets (i.e. UNICEF MICS, Parent Ladder). Group comparisons were made using multivariable regression analyses, adjusting for caregiver-, infant- and household-level demographic characteristics.
Results: At completion, children in the intervention group scored meaningfully higher across all EASQ domains, compared to children in the control group: communication (δ=0.21, 95%CI: 0.07-0.26), social development (δ=0.27, 95%CI: 0.11-28), and motor development (δ=0.33, 95%CI: 0.14-0.31). Caregivers in the intervention group also reported significantly higher adjusted odds of engaging in positive caregiving practices in four of six MICS domains, compared to caregivers in the control group—including book reading (AOR: 3.77, 95%CI: 1.94-7.29) and naming/counting (AOR: 2.05; 95%CI: 1.24-3.71).
Conclusions: These results suggest that integrating an ECD intervention into a rural primary care platform, such as in the Lesothoan context, may be an effective and efficient way to promote early child development outcomes.

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ARTICLE SUMMARY

Strengths and limitations of this study

- This study shows that strong findings from a community-based early child development intervention developed for a culturally distinct resource-limited setting had sustained impact when adapted for hybrid clinic/community delivery in a rural African setting.
- This impact extends beyond ECD outcomes to caregiver engagement and caregiver/child interaction.
- Newborns and very young infants benefitted equally to older children, showing these interventions should start early.
- The use of an extended version of the Ages and Stages Questionnaire facilitated uptake but could introduce bias as it is a parent report tool.
- We were unable to include patients in dissemination activities and in the future would extend patient involvement even further.

INTRODUCTION

The period from prenatal development to three years of age is one of the most critical stages of brain development [1]. Malnutrition and stunting [2, 3] threaten to deny an estimated 250 million children under five (43%) with the opportunity to reach their full developmental potential [4]. Social forces common in lower and middle income countries (LMICs), such as violence, abuse and neglect trigger the body's stress response system that can remain chronically activated into adulthood, straining the cardiovascular and central nervous systems [5, 6]. The impact of the culmination of these forces may be irreversible and contribute to a cycle of poverty, inequality, and social exclusion [7, 8]. Caregivers have the unique opportunity to engage in positive interactions with their children beginning at a very young age, which have been proven to nourish and even reverse this damage [9-11].

For this reason, attention has been given to finetuning strategies to reach children living in poverty in LMICs through early childhood development (ECD) programs [12-14]. Many such programs have improved ECD, caregiver behavior, and school readiness, however, particularly in rural LMICs, they are primarily facility or center-based

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interventions, where caregivers deliver their child to a trained professional for stimulation activities [15].

While integrated facility-community interventions are rapidly becoming the norm, facility-based studies such as that by Chang and colleagues' (2015) caregiving intervention in Jamaica demonstrate that facility-based programs are effective in promoting cognitive development for children up to 18 months old [16]. This approach has the benefit of facilitating training and delivery for practitioners, but there may be shortcomings in terms of scale up and sustainability. Health facilities in rural low-resource settings are routinely overwhelmed by the volume of patients presenting with physical health conditions and ECD screening is sidelined. Caregivers of physically healthy children may have little incentive to attend health clinics located long distances from their home and therefore participation may be low. Caregivers in Lesotho, for instance, walk up to 10 hours each way to reach a health center. The salary for a mental health professional in a clinical setting can be prohibitive when hospitals manage tight budgets and urgently needed health supplies and physicians may be prioritized. Home- and community-based programs benefit from the low-cost of a community workforce [17]. Likewise, in home or community -based visitation programs, the family can participate. The family environment is widely accepted as a central focus for intervention, including social support and/or self-esteem building of the caregivers [18]. Community workers are experts in local knowledge and the can be allies in adaptation of curricula to local contexts, an area of ECD interventions in LMICs that is receiving increasing attention from ECD scholars [19].

For this study, the team in Lesotho developed a hybrid community/clinic-based ECD intervention adapted from two ECD interventions which have shown impact in other rural LMICs. Village health workers (VHWs) delivered the home-based intervention as part of their routine activities, while leveraging post-natal care visits—during which caregivers are

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already attending primary care facilities with their children for immunizations—for enrollment and ECD intervention initiation [20].

This pilot study evaluates the impact of this hybrid delivery model on ECD outcomes and caregiving practices by comparing a cohort of caregiver-infant (7-11 month-old) dyads who received the intervention, to a comparable cohort that did not receive the intervention. We hypothesized that the delivery model would successfully engage parent-child dyads, and that the intervention would increase developmentally-supportive parenting practices in turn improving developmental outcomes.

MATERIALS AND METHODS

Study Setting

This study took place within the catchment area of Nkau Health Center in the district of Mohale's Hoek District, Lesotho. Nkau Health Center is a rural, mountainous clinic in Lesotho southwestern region, with an estimated catchment population of 15,000 persons as of 2016 (Lesotho Ministry of Health and ICF International, 2016). The health center is a public government facility supported by the medical NGO Partners In Health. Two types of VHWs are integrated into primary healthcare teams across all villages in the catchment area, with one VHW cadre focused on HIV and TB, and the other focused on maternal and child health.

Intervention

This program was developed from an existing program called CASITA which showed positive impact at scale in rural LMIC settings [21]. A community-based ECD intervention in Carabayllo, a low-resource community outside of Lima, Peru, CASITA was developed by our sister organization Socios En Salud (Partners In Health Succursal Peru) and is now scaling up to over 3,455 children. CASITA, adapted for use from the SPARK Center's ECD

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program for children living in poverty at Boston Medical Center, involves four featured components of ECD training sessions: 1) knowledge sharing about child development and child observation; 2) demonstration and initiation of social interaction activities tailored to the child's development; 3) caregiver encouragement on caregiving behavior and development interactions; and 4) caregiver social support and reassurance. In the pilot study, children ages 6-24 months who screened at risk of delay received either individual home-visits or group sessions with this curriculum, along with nutritional supplements. Those in the intervention group improved ECD significantly compared to the control group in all areas of delay [14]. Caregivers and community health representatives widely agreed that individual home visits and group gatherings in local community centers outside of the clinic was central to its success [14]. We borrowed the curricula and session structure and spacing from CASITA.

Patient and Public Involvement

During adaptation, each aspect of the curricula was reviewed with the CASITA researcher (AKN) and the ECD Nurse (RL) at the village health center were conducted in May 2017. Draft adaptations were noted on all curricula materials and then discussed with one VHW and one local mother. Final changes were made on consensus with the on-site Principal Investigator (MN) and Maternal and Child Health Program Manager (JM). Two to three patients were involved in the adaptation of the intervention. Women received the intervention in a draft phase and were asked about their reactions. Opinions were incorporated into the intervention design. Care was taken to consider local childrearing practices, of particular importance given increased concern about the cultural relevance of ECD interventions being transposed to LMICs from other contexts [19]. Findings from this study will not be formally shared with study participants, however, health professionals at the

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clinic will be presented with the findings through a staff meeting and may respond to patients questions during clinical visits.

Study design

This is a prospective case control pilot study to test the impact of an early intervention with a hybrid delivery model on 1) improved ECD outcomes, 2) caregiver-child interaction, and 3) developmentally-supportive caregiving practices. The latter two were chosen as they have been shown to be mediators between ECD interventions focused on parent coaching and ECD outcomes.

Recruitment for the control and intervention groups started in May and July 2017, respectively. For the intervention group, dyads with children ages 0-6 weeks receiving postnatal care (PNC) services at health clinics in Mohale's Hoek were recruited and offered enrollment in the intervention. Children who were born more than two weeks prematurely and with severe developmental delays were excluded.

As a control comparison, we identified a cohort of caregiver-infant dyads residing in the same catchment area, among whom infants were already 7-11 months old and therefore not eligible for the intervention. Comparison dyads were assessed with the same set of measures as the intervention group, solely during the intervention group's baseline period. As such, the comparison of interest was between the intervention group at end line (when infants were 7-11 months old) versus the control group at baseline (when infants were 7-11 months old). The comparisons were adjusted using all demographic information and covariates.

Study Sample

259 dyads were screened. Of these 259 dyads, 255 were enrolled: 125 dyads in the control group and 130 dyads in the intervention group were included. No families refused

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participation. Three children were born prematurely and one child was found to have mild to severe developmental delays and thus, were excluded from the sample. At the point of analysis within the intervention group, nine dyads withdrew from the study, two were deceased, and one of a set of twins was removed from analysis to prevent bias occurring from including multiple children within a single household **[Figure 1].**

All dyads in the intervention group were invited to participate in seven caregiver education sessions. Sessions at weeks 6, 10, 14, and 18 took place at Nkau Health Center and were conducted by a trained ECD nurse in a group setting. These dates corresponded to Lesotho's national immunization schedule, so families did not have to travel to the clinic for additional visits. Caregivers who either couldn't make group sessions due to scheduling or missed sessions were targeted for individual outreach by VHWs. Of the 119 participating dyads, 100% completed sessions at 6, 10, and 14 weeks, and 83 (70%) completed the final session at 18 weeks. The remaining three sessions (8, 12 and 16 weeks) were conducted by maternal health VHWs in dyads' households. Of those, 88 (74%) completed the 8 week session, 75 (63%) completed the 12 week session, and 85 (71%) completed the 16 week session. VHWs were charged with leading these sessions as they work primarily in the community, whereas ECD nurses are based in the clinic. The ECD nurse conducted unannounced spot checks of VHWs to ensure they were conducting the intervention as intended. After the seven sessions were completed, VHWs continued to conduct regular home visits focused on maternal and child health.

There were two deviations from the original program design that should be noted: while the intervention was based on group sessions at health centers, flooding and scheduling challenges within villages required unanticipated one-on-one sessions by VHWs. Caregivers

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who missed sessions required targeted outreach, including additional VHW visitations to homes to ensure all caregivers received the complete intervention.

Training

One researcher involved in creating and piloting CASITA traveled to Lesotho and trained 80 VHWs together with the head ECD nurse, who in turn coached caregivers while modeling positive caregiving behaviors. Training took place at the Nkau Health Center over three days and all VHWs traveled to the clinic to attend. Training involved lecture-style sessions in English with video examples of key concepts, translated into Sesotho, didactic small-group discussions, and practice with individualized feedback. Refresher trainings for the Village Health Workers were conducted on monthly basis during the VHWs monthly meetings at the clinics.

Measures

ECD Measures. ECD was assessed using the Extended Ages and Stages Questionnaire (EASQ), an adapted version of the Ages and Stages Questionnaire (ASQ) [22], with the same questions presented in continuous format, allowing for pre- and post- score comparison across ages [14, 23]. The ASQ is widely used internationally and screens for developmental risk with three domains: communication (e.g. “If you repeat the sounds your baby makes, does s/he repeat them again after you?”), social/personal development (e.g. “When you reach out your hand to ask for a toy, does baby hand it to you?”), and motor development (e.g. “When your baby is lying face down, can he stretch his arms and lift his chest off the bed or floor?”). Response options are yes, sometimes, and no. A few words on the EASQ were changed for applicability in Sesotho. For instance, on the 4-6 Month item #25.7.10 which

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reads, “Does your baby make rounds like “ma,” “da,” “ga,” “ca” and “ba”? “, the team removed “ga” and “ca” and added “aaa” and “na” to mimick early sounds in Sesotho.

Caregiver Measures. Caregiver engagement was measured using the self-report Parent Ladder [24], an omnibus measure of caregiver engagement designed to measure knowledge, skills and behavior. This scale contains 12 items on a seven-point ordinal scale ranging from 0 (lowest) to 6 (highest) with questions such as “Knowledge of how my child is growing and developing?” and “Ability to identify my child’s needs?”. The global score was used to measure caregiver engagement. Second, six questions from UNICEF’s Multiple Indicator Cluster Survey: for Children Under Five [25] were selected to measure in-home caregiver-child interaction. Questions contain four multiple-response options (“mother”, “father”, “other”, “no one”), and questions such as: “In the past 3 days, did you or any household member engage in any of the following activities with your baby: (1) Read books or looked at a picture books with baby?” and “(2) …sang songs to baby, including lullabies?”.

All measures were translated into Sesotho by a certified translator and checked with the ECD nurse fluent in English, then double-checked with the site PI and MCH program manager to ensure meaning was correct. All questions regarding meaning were discussed with a Boston-based ECD researcher.

Caregiver socioeconomic status was measured by educational attainment and household assets. Depressive symptoms were measured using the PHQ-9 [26]. Other covariates such as sex, age, height/length, and weight, were recorded for each child at every data collection point.

Statistical Analysis

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It was determined that 250 participants must be enrolled in order to detect statistical significance of alpha = .05 with a power of .80 for the primary outcome variables. As a preliminary review of the data, correlations between the outcome variables and covariates were inspected using Pearson coefficients. Bivariate analyses then examined individual relationships between independent variables (see above) and outcomes of interest. Based on these preliminary analyses, we identified a consistent pattern of expected associations, indicating acceptable concurrent validity, and did not identify any correlations that were so strong ($r>0.70$) they may be indicative of collinearity in statistical models.

Following preliminary review, the intervention and control groups were compared using univariate and multivariable regression analysis: multivariable linear regression for continuous outcomes such as child EASQ scores, and multivariable logistic regression for binary outcomes, such as caregiving behaviors, documented in the MICS survey. These comparisons examined child development outcomes and caregiving outcomes between groups, adjusting for covariates in order to safeguard against omitted variable bias. Analyses Used STATA's xtreg command to account for autocorrelation and clustering of multiple data points within individuals over time (StataCorp, 2017).

EASQ analysis was stratified by the test age group (7-9 month vs. 10-11 month), and then merged with a dummy variable to represent test type. To ensure appropriateness of intervention and control group comparisons, dyads were compared when infants were within the same age group: namely, 7-11 months old.

RESULTS

The control and intervention groups were similar across most demographic characteristics, including immunization completion rates and percentage of facility-based deliveries. Caregivers in the intervention were slightly more educated and younger, and

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scored modestly higher on the PHQ-9 depression score at endline, as well as reporting more frequent antenatal care visits. Children of caregivers in the intervention group were slightly younger and had lower anthropomorphic z-scores. Table 1 contains detailed demographic indicators. All covariates were incorporated in final multivariable regression models, regardless of statistical significance, as we determined relevance of covariates a priori based on evidence in child development literature. Of the 119 participating dyads, 100% completed all sessions until 14 weeks, and 83 (70%) completed the final session. All those completing 14 sessions were included in final analysis, with the exception of one twin who was removed to prevent family bias. In the end, 243 participants had final outcome data.

[Insert Table 1]

Early Child Development Outcomes

Adjusting for covariates, at endline, children in the intervention group scored higher on EASQ measures across all domains: total score, communication, social, and motor development. Moreover, these results were consistent regardless of whether the age range was restricted to 7-9 months at endline, 10-11 months at endline, or pooled, with the one exception being communication in the 7-9 month group, for which the intervention group observed non-significantly higher scores (p=0.08). An overview of results, measured in terms of standard deviation (SD) improvements from baseline to endline, is presented in Table 2.

[Insert Table 2]

Caregiver Outcomes

Results also indicated marked improvement on the Parent Ladder in the intervention group compared to the control group. Caregivers in the intervention group were 17 points

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higher at endline (44%), compared to the control group (δ=1.57, p<0.001). Differences remained significant (δ=0.56, p<0.05) after adjusting for covariates in the context of multivariate regression.

Similarly, the intervention was associated with greater odds of affirmative responses on all but one MICS items (Table 3). MICS results suggested that caregivers in the intervention group were: 3.7 times more likely to read a book to their child in the past three days, 13.8 times more likely to tell stories, 2.3 times more likely to sing songs, 2.8 times more likely to engage in play, and 2.1 times more likely to name, count, or draw with their child.

[Insert Table 3]

DISCUSSION

We implemented an early childhood development intervention in the Nkau Health Center catchment area of Mohale's Hoek, Lesotho, one of the more rural, remote regions of the country. A total of 130 dyads were enrolled in the intervention over a 6-month period, representing the vast majority of new mothers (>90%) attending clinic. As such, our findings suggest acceptability and feasibility for broad implementation in similar rural settings, including other districts of Lesotho. More importantly, the intervention indicated marked positive impacts on both children and caregivers enrolled.

Children whose caregivers participated in the ECD intervention observed significantly greater improvements in all developmental domains compared to a control group of the same age range. Associated effect sizes were also clinically meaningful—particularly in the older age range of 9-11 month-old infants, where group standardized mean differences ranged from 0.30 to 0.50 after adjusting for covariates. We found that caregivers in the intervention group significantly improved their caregiving skills, knowledge and confidence, relative to those in

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the control group and were more likely engage in interactions with children following receipt of the intervention.

While several studies have shown ECD improvements through caregiver interventions [27-29], most interventions in LMICs have targeted children older than one year [30]. One study, conducted in another rural region of Lesotho still underway, is engaging children ages 1-5 and their caregivers in eight sessions that included HIV and nutritional education and an ECD component involving book sharing to encourage caregiver-child engagement [31]. Likewise, a community-based caregiver intervention by Singla and colleagues (2015) in Uganda resulted in cognitive improvements among children aged 12-36 months [32]. Evidence from high-resource settings indicates that ECD interventions targeted at this first year of child development may be particularly beneficial [11, 33], as the impacts on caregiving behaviors and developmental outcomes are likely to carry forward over the course of childhood. Our study shows this may also true in settings of poverty within LMICs.

Our study employed a strategic hybrid delivery model. As such, integrating ECD interventions into postnatal care services, as modeled in our study, offers a convenient way for caregivers to learn about cognitive development and child stimulation techniques while already in attendance at clinics, at a very early stage in the child's life. Lessons provided at clinics can then be reinforced through VHWs who are operating in community-based settings, further reducing the onus that might otherwise be placed on caregivers to attend educational sessions. Several new studies are enrolling participants using a similar integrated model in other LMICs such as Bangladesh [12].

Even still, ECD interventions in low-resource settings may be forgone because scarce resources limit government capacity to equip health facilities and train health care workers [34, 35]. These tradeoffs are inherent in many budgetary decisions, where maternal and child health are underfunded relative to other clinical care domains [36, 37]. Furthermore, rural

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communities often lack information provided through the internet and other e-learning platforms that might otherwise educate physicians, healthcare professionals and caregivers on how to encourage children's cognitive and physical development [38, 39]. In such context, enhanced caregiver knowledge through ECD interventions based in the community may be introduced at low cost by building off of existing primary health care infrastructure. The framework outlined in this study offers a successful illustration of this.

A few study limitations should be mentioned. There is a potential for unmeasured differences between the intervention and control groups, which could account for some level of difference in ECD outcomes. We attempted to mitigate this possibility by gathering a wide range of covariates. Likewise, magnitude of the observed impact of the intervention was sizable, making a Type 1 error relatively unlikely.

A third consideration is participant response bias. Measures were dependent on self-reports of caregivers and repeated administration of tests. It is possible, for example, that those in the intervention group believed survey administrators wanted to hear that caregiving behavior and ECD outcomes improved over time. This could overestimate the impact of the intervention on ECD. The fact that this intervention was adapted from a mixed urban and rural setting in Peru may suggest the external validity of the program. However, its use in other African settings would depend on the similarity of the culture and setting and the careful adaptation of the content.

Further research calls on qualitative data such as focus groups to understand what aspects of the intervention were useful and how the caregivers believed their practices changed in response to the sessions.

CONCLUSIONS

This study demonstrated significant effects of an ECD intervention on early child development, as well as caregiver knowledge and skills. The intervention was implemented

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with few resources by leveraging existing human resources and health system infrastructure. Based on this, we are hopeful to scale the intervention more broadly in districts throughout rural Lesotho.

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Table 1: Baseline Characteristics of Intervention and Control Groups

Demographic Measures: Binary	Control Group N (%)	Intervention Group N (%)
Caregiver		
Female	124 (99%)	117 (99%)
Primary school complete	71 (57%)	84 (71%)*
Birth at home	10 (8%)	13 (11%)
Infant		
Female	73 (58%)	65 (55%)
Evidence of wasting	14 (11%)	22 (18%)*
Evidence of stunting	5 (4%)	6 (5%)
Underweight	7 (6%)	10 (8%)*
Fully Immunized at 9 months	125 (100%)	112 (95%)
Demographic Measures: Continuous	**Mean (SD)**	**Mean (SD)**
Caregiver		
Age (years)	26.01 (7.18)	23.50 (6.32)*
Parity	2.18 (1.56)	2.06 (1.50)
Gravida	2.27 (1.64)	2.21 (1.68)
Pregnancy weeks at birth	38.82 (1.72)	38.79 (1.50)
ANC visits	3.03 (1.16)	3.35 (1.04)*
Household members	5.92 (2.12)	5.75 (2.19)
Depression score	2.98 (3.08)	5.18 (5.18)*
Infant		
Age (months)	9.40 (0.32)	9.30 (0.31)*
Weight for height	-0.44 (1.45)	-1.03 (1.22)*
Length for age	0.75 (2.08)	0.69 (1.63)*
Weight for age	0.12 (1.22)	-0.60 (1.02)*

** Difference between control and intervention groups p<.05*

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Table 2: Early Child Development Outcomes on EASQ – Difference by Group

EASQ Category	Mean Difference	95% CI	Standardized Coefficient	95% CI	Adj R^2	Obs.
Communication						
EASQ 7-9 month	0.11	0.03 - 0.18	0.09	-0.03 - 0.14	0.08	184
EASQ 10-11 month	0.50*	0.23 – 0.76	0.34*	0.14 - 0.62	0.41	59
Combined	0.27*	0.00 - 0.18	0.21*	0.07 - 0.26	0.22	243
Social Development						
EASQ 7-9 month	0.11*	0.03 - 0.19	0.15*	0.01 - 0.17	0.07	184
EASQ 10-11 month	0.49*	0.26 - 0.73	0.42*	0.20 - 0.63	0.42	59
Combined	0.27 *	0.19 - 0.36	0.27*	0.11 - 0.28	0.26	243
Motor Development						
EASQ 7-9 month	0.14*	0.07 - 0.21	0.26*	0.07 - 0.24	0.05	184
EASQ 10-11 month	0.46*	0.20 - 0.71	0.46*	0.23 - 0.75	0.19	59
Combined	0.22*	0.16 - 0.32	0.33*	0.14 - 0.31	0.12	243
Total Score						
EASQ 7-9 month	0.12*	0.06 - 0.18	0.21*	0.03 - 0.17	0.06	184
EASQ 10-11 month	0.48*	0.30 - 0.66	0.51*	0.26 - 0.60	0.48	59
Combined	0.24*	0.20 - 0.33	0.32*	0.13 - 0.27	0.26	243

*Notes: *p<0.05. Adjusted multivariable regression included child sex and age, as well as caregiver education, socioeconomic status, and fixed effects for research staff members conducting the assessment. "95% CI stands for 95% Confidence Interval.*

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Table 3. Caregiver Engagement – Difference by Group

MICS Measure	Adj. OR	95% CI	Pseudo R^2
Read book	3.77*	1.94 - 7.29	0.14
Told stories	13.75*	6.32 – 29.90	0.27
Sang songs	2.29 *	1.09 - 4.83	0.08
Took outside	1.49	0.76 – 2.90	0.05
Actively played	2.83	0.86 - 9.21	0.12
Named/counted	2.05*	1.24 - 3.71	0.07

*Notes: *p<0.05. Adjusted multivariable regression included child sex and age, as well as caregiver education, socioeconomic status, and fixed effects for research staff members conducting the assessment. "Adj. OR" stands for "Adjusted Odds Ratio" and "95% CI" stands for "95% Confidence Interval of the Adjusted Odds Ratio".*

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Figure 1. Study Flow Diagram

Notes: The control group comprised caregiver-infant dyads in which infants were 7-11 months-old in May-July 2017, the recruitment period. Caregiver-infant dyads in the control group were assessed immediately upon study enrolment only. The intervention group comprised caregiver-infant dyads in which infants were 0-2 months in May-July 2017. Caregiver-infant dyads in the intervention group were assessed three times (baseline, midterm, final assessment), with baseline assessment conducted immediately upon study enrollment and final assessment conducted seven months later, when infants were 7-11 months-old.

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Contributorship statement

All authors reviewed manuscript drafts and consented to the final submitted version.

Adrianne Katrina Nelson, Principal Investigator of the pilot CASITA study, facilitated intervention and measurement tool translation and adaptation for this study. She traveled to Lesotho to train MJ, the study coordinator, and the village health workers in the intervention. She co-wrote the manuscript and was in charge of submission and correspondence.

Melino Ndayizigiye is the Principal Investigator for this study. He is responsible for writing the grant, securing funding, representing the study at international conferences, and interfacing with the ethics committee and US-based investigators. He oversaw on-site study activities and managed Lesotho site staff.

Collin Whelley conducted all data management and analysis with the help of AM.

Rorisang Lerotholi, the study coordinator, reviewed translated assessment and intervention materials, translated during village health worker trainings, consulted on adaptations, conducted fidelity checks on interventions, and collected data for analysis.

Joalane Mabathoana, the then Maternal and Child Health Program Manager at Partners In Health, Lesotho managed the study coordinator and participated in adaptation of materials and training of village health workers.

Carmona, Merida, was in charge of donor compliance and study design.

Curtain, Joe developed the study design with Ms. Carmona.

Birru, Ermyas developed data collection instruments, consulted on data components of the study design, analysis and review of the manuscript.

Sara Stulac is a pediatrician and co-investigator on this grant with experience working in Lesotho. She delivered expertise in the field of early child development and pediatrics.

Ann C. Miller is the epidemiologist responsible for data analysis for the CASITA project. She provided analytical for this study guidance to CW, specifically for the EASQ, including coding for score standardization.

Sonya S. Shin is the senior researcher for the CASITA project and provided high level mentorship to AKN in the adaptation of the study intervention and training of village health workers.

Nancy Rumaldo is the site leader of the CASITA project and provided field-level consultation during the adaptation and training in Lesotho.

Mukherjee, Joia was the senior clinician in charge of overseeing the clinical components of the study.

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McBain, Ryan K. is the US-based study lead who joined in the analysis phase. He was in charge of coordinating co-investigators, supervising data analysis, and co-writing the manuscript.

Competing interests

Authors report no competing interests.

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Data sharing statement

Extra data is available by emailing Collin Whelley at collinwhelley@gmail.com

Ethics statement

The study was reviewed and approved by the Lesotho National Ethics Committee approval reference #ID51-2017.

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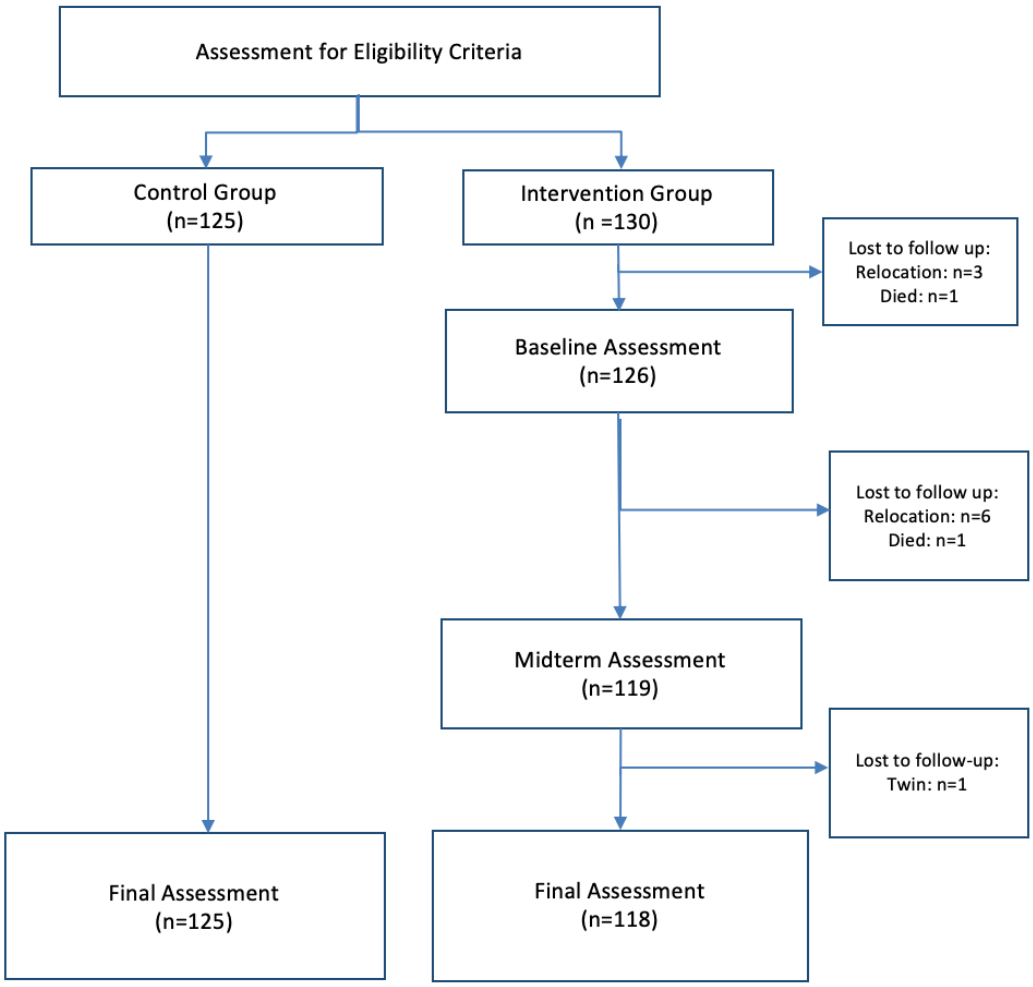
Figure 1. Study Flow Diagram



Notes: The control group comprised caregiver-infant dyads in which infants were 7-11 months-old in May-July 2017, the recruitment period. Caregiver-infant dyads in the control group were assessed immediately upon study enrolment only. The intervention group comprised caregiver-infant dyads in which infants were 0-2 months in May-July 2017. Caregiver-infant dyads in the intervention group were assessed three times (baseline, midterm, final assessment), with baseline assessment conducted immediately upon study enrollment and final assessment conducted seven months later, when infants were 7-11 months-old.

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STROBE Statement—Checklist of items that should be included in reports of ***case-control studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7-8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls	9
		(*b*) For matched studies, give matching criteria and the number of controls per case	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	11-12
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	11-12
Bias	9	Describe any efforts to address potential sources of bias	13
Study size	10	Explain how the study size was arrived at	13
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	11-12
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	13
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	13
		(*d*) If applicable, explain how matching of cases and controls was addressed	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10
		(b) Give reasons for non-participation at each stage	10
		(c) Consider use of a flow diagram	22
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	19
		(b) Indicate number of participants with missing data for each variable of interest	14
Outcome data	15*	Report numbers in each exposure category, or summary measures of exposure	14

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Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	14-15, Table 2
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	17-18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17
Generalisability	21	Discuss the generalisability (external validity) of the study results	18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	13

*Give information separately for cases and controls.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

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Integrating an Early Child Development Intervention into an Existing Primary Health Care platform in Rural Lesotho: A prospective Case Control Study

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TITLE

Integrating an Early Child Development Intervention into an Existing Primary Health Care platform in Rural Lesotho: A prospective Case Control Study

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Ndayizigiye, Melino[1]; McBain, Ryan K. [2] Whelley, Collin[3]; Rorisang Lerotholi[1], Mabathoana, Joalane[1]; Carmona, Merida [3]; Curtain, Joe[3] ; Birru, Ermyas[4]; Stulac, Sara[5]; Miller, Ann C.[6]; Shin, Sonya S.[7]; Rumaldo, Nancy[8]; Mukherjee, Joia[3,6]; Nelson, Adrianne Katrina[9]

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ABSTRACT

Objectives: This study evaluated a novel early child development (ECD) program integrated it into the primary healthcare system.
Setting: The intervention was implemented in a rural district of Lesotho from 2017-2018.
Participants: It targeted primary caregivers during routine post-natal care visits and through village health worker home visits.
Intervention: The hybrid care delivery model was adapted from a successful program in Lima, Peru and focused on parent coaching for knowledge about child development, practicing contingent interaction with the child, parent social support and encouragement.
Primary and secondary outcomes measures: We compared developmental outcomes and caregiving practices in a cohort of 130 caregiver-infant (ages 7-11 months-old) dyads who received the ECD intervention, to a control group that did not receive the intervention (n=125) using a case-control study design. Developmental outcomes were evaluated using the Extended Ages and Stages Questionnaire (EASQ), and caregiving practices using two measure sets (i.e. UNICEF MICS, Parent Ladder). Group comparisons were made using multivariable regression analyses, adjusting for caregiver-, infant- and household-level demographic characteristics.
Results: At completion, children in the intervention group scored meaningfully higher across all EASQ domains, compared to children in the control group: communication (δ=0.21, 95%CI: 0.07-0.26), social development (δ=0.27, 95%CI: 0.11-28), and motor development (δ=0.33, 95%CI: 0.14-0.31). Caregivers in the intervention group also reported significantly higher adjusted odds of engaging in positive caregiving practices in four of six MICS domains, compared to caregivers in the control group—including book reading (AOR: 3.77, 95%CI: 1.94-7.29) and naming/counting (AOR: 2.05; 95%CI: 1.24-3.71).
Conclusions: These results suggest that integrating an ECD intervention into a rural primary care platform, such as in the Lesothoan context, may be an effective and efficient way to promote early child development outcomes.

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ARTICLE SUMMARY

Strengths and limitations of this study

Unlike early child development programs adapted for lower resources settings from wealthier settings, this intervention was created and piloted in another rural LMIC (Peru).

The study demonstrated feasibility of integration of an ECD intervention in primary health care in rural and low resource settings

The use of an extended version of the Ages and Stages Questionnaire facilitated uptake but could introduce bias as it is a parent report tool.

While translations were done by a certified translator and then reviewed by study staff, the parenting measures, in particular the Parent Ladder, were not formally adapted and validated for this context.

We were unable to include patients in dissemination activities and in the future would extend patient involvement even further.

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INTRODUCTION

The period from prenatal development to three years of age is one of the most critical stages of brain development [1]. Malnutrition and stunting [2, 3] threaten to deny an estimated 250 million children under five (43%) with the opportunity to reach their full developmental potential [4]. Social forces common in low- and middle-income countries (LMICs), such as violence, abuse and neglect trigger the body's stress response system that can remain chronically activated into adulthood, straining the cardiovascular and central nervous systems [5, 6]. The impact of the culmination of these forces may be irreversible and contribute to a cycle of poverty, inequality, and social exclusion [7, 8]. For this reason, attention has been given to finetuning strategies to reach children living in poverty in LMICs through early childhood development (ECD) programs [9-11]. Many such programs have improved ECD, however, particularly in rural LMICs, they are primarily clinic or center-based interventions. Clinic-based studies such as that by Chang and colleagues' (2015) caregiving intervention in Jamaica demonstrate that clinic-based programs are effective in promoting cognitive development for children up to 18 months old [12]. This approach has the benefit of facilitating training and delivery for practitioners, but there may be shortcomings in terms of scale up and sustainability. Clinics in rural low-resource settings are routinely overwhelmed by the volume of patients presenting with physical health conditions and ECD screening is sidelined. The salary for a mental health professional in a clinical setting can be prohibitive when hospitals manage tight budgets and urgently needed personal and supplies are likely to be prioritized.

Caregivers of physically healthy children may have little incentive to attend clinics located long distances from their home and therefore participation may be low. Caregivers in Lesotho, for instance, walk up to 10 hours each way to reach a health center. This may be why community-based and integrated clinic-community interventions are rapidly becoming

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the norm. Home- and community-based programs benefit from the low-cost of a community workforce [13]. Likewise, in home or community -based visitation programs, the family can participate. The family environment is widely accepted as a central focus for intervention, including social support and/or self-esteem building of the caregivers [14]. Caregivers have the unique opportunity to engage in positive interactions with their children beginning at a very young age, a practice which has been proven to nourish and even reverse early delay [15-17]. Community workers are experts in local knowledge and can be allies in adaptation of curricula to local contexts, an area of ECD interventions in LMICs that is receiving increasing attention from ECD scholars [18].

For this study, the team in Lesotho developed a hybrid community/ clinic-based ECD intervention adapted from two ECD interventions which have shown impact in other rural LMICs. Village health workers (VHWs) delivered the home-based intervention as part of their routine activities, while leveraging post-natal care visits—during which caregivers are already attending primary care facilities with their children for immunizations—for enrollment and ECD intervention initiation [19].

This pilot study evaluates the impact of this hybrid delivery model on ECD outcomes and caregiving practices by comparing a cohort of caregiver-infant (7–11-month-old) dyads who received the intervention, to a comparable cohort that did not receive the intervention. We hypothesized that the delivery model would successfully engage parent-child dyads, and that the intervention would increase developmentally supportive parenting practices in turn improving developmental outcomes.

MATERIALS AND METHODS

Study design

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This is a prospective case control pilot study to test the impact of an early intervention with a hybrid delivery model on 1) improved ECD outcomes, 2) caregiver-child interaction, and 3) developmentally supportive caregiving practices. The latter two were chosen as they have been shown to be mediators between ECD interventions focused on parent coaching and ECD outcomes.

Study Setting

This study took place within the catchment area of Nkau Health Center in the district of Mohale's Hoek District, Lesotho. Nkau Health Center is a rural clinic in Lesotho's mountainous southwestern region, with an estimated catchment population of 15,000 persons as of 2016 (Lesotho Ministry of Health and ICF International, 2016). The health center is a public government clinic supported by the medical NGO Partners In Health. Two types of VHWs are integrated into primary healthcare teams across all villages in the catchment area, with one VHW cadre focused on HIV and TB, and the other focused on maternal and child health.

Intervention

This program was developed from an existing program called CASITA which showed positive impact at scale in rural LMIC settings [20]. A community-based ECD intervention in Carabayllo, a low-resource community outside of Lima, Peru, CASITA was developed by our sister organization Socios En Salud (Partners In Health Succursal Peru) and is now scaling up to over 3,455 children. CASITA, adapted for use from the SPARK Center's ECD program for children living in poverty at Boston Medical Center, involves four featured components of ECD training sessions: 1) knowledge sharing about child development and child observation; 2) demonstration and initiation of social interaction activities tailored to

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the child's development; 3) caregiver encouragement on caregiving behavior and development interactions; and 4) caregiver social support and reassurance. In the pilot study, children ages 6-24 months who screened at risk of delay received either individual home-visits or group sessions with this curriculum, along with nutritional supplements. Those in the intervention group improved ECD significantly compared to the control group in all areas of delay [11]. Caregivers and community health representatives widely agreed that individual home visits and group gatherings in local community centers outside of the clinic was central to its success [11]. We borrowed the curricula and session structure and spacing from CASITA (Table 1a and b).

[Insert Table 1a and b]

All dyads in the intervention group were invited to participate in seven caregiver education sessions of 4-6 dyads each. Sessions at weeks 6, 10, 14, and 18 took place at Nkau Health Center and were conducted by a trained ECD nurse in a group setting. These dates corresponded to Lesotho's national immunization schedule, so families did not have to travel to the clinic for additional visits. Caregivers who either couldn't make group sessions due to scheduling or missed sessions were targeted for individual outreach by VHWs. Of the 119 participating dyads, 100% completed sessions at 6, 10, and 14 weeks, and 83 (70%) completed the final session at 18 weeks. The remaining three sessions (8, 12 and 16 weeks) were conducted by maternal health VHWs in dyads' households. Of those, 88 (74%) completed the 8-week session, 75 (63%) completed the 12-week session, and 85 (71%) completed the 16-week session. VHWs were charged with leading these sessions as they work primarily in the community, whereas ECD nurses are based in the clinic. The ECD nurse conducted unannounced spot checks of VHWs to ensure they were conducting the intervention as intended. An assessment form was completed by the ECD nurse indicating whether each activity was completed as intended. She met with the VHW after the visit and

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reviewed the assessment. VHWs were given an additional individual training session if one part of the session was not completed accurately. After the seven sessions were completed, VHWs continued to conduct regular home visits focused on maternal and child health.

There were two deviations from the original program design: while the intervention was based on group sessions at health centers, flooding and scheduling challenges within villages required unanticipated one-on-one sessions by VHWs. Caregivers who missed sessions required targeted outreach, including additional VHW visitations to homes to ensure all caregivers received the complete intervention.

Training

One researcher involved in creating and piloting CASITA traveled to Lesotho and trained 80 VHWs together with the head ECD nurse, who in turn coached caregivers while modeling positive caregiving behaviors. Training took place at the Nkau Health Center over three days and all VHWs traveled to the clinic to attend. Training involved lecture-style sessions in English with video examples of key concepts, translated into Sesotho, didactic small-group discussions, and practice with individualized feedback. Refresher trainings for the Village Health Workers were conducted on monthly basis (four total) during the VHWs regular meetings at the clinic. During this meeting, all 80 VHWs practiced delivering home sessions for which they received feedback and the opportunity to clarify questions arising in the field. The ECD nurse reviewed the home visit agenda at each meeting and focused on problem areas observed during her unannounced fidelity visits. Refresher trainings lasted approximately two to three hours each.

Patient and Public Involvement

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During adaptation, each aspect of the Lesothoan curricula was reviewed with the CASITA researcher (AKN) and the ECD Nurse (RL) at the village health center in May 2017. Draft adaptations were noted on all curricula materials and then discussed with one VHW and one local mother. Final changes were made on consensus with the on-site Principal Investigator (MN) and Maternal and Child Health Program Manager (JM). Two to three patients were involved in the adaptation of the intervention. Women received the intervention in a draft phase and were asked about their reactions. Opinions were incorporated into the intervention design. Care was taken to consider local childrearing practices, of particular importance given increased concern about the cultural relevance of ECD interventions being transposed to LMICs from other contexts [18]. Findings from this study will not be formally shared with study participants, however, health professionals at the clinic will be presented with the findings at a staff meeting and invited to respond to patients' questions during clinical visits.

Study Sample

Recruitment for the control and intervention groups started in May and July 2017, respectively. For the intervention group, dyads with children ages 0-6 weeks receiving postnatal care (PNC) services at clinics in Mohale's Hoek were recruited and offered enrollment in the intervention. Children who were born more than two weeks prematurely and with severe developmental delays were excluded.

As a control comparison, we identified a cohort of caregiver-infant dyads residing in the same catchment area, among whom infants were already 7-11 months old and therefore not eligible for the intervention. Comparison dyads were assessed with the same set of measures as the intervention group, solely during the intervention group's baseline period. As such, the comparison of interest was between the intervention group at end line (when infants

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were 7-11 months old) versus the control group at baseline (when infants were 7-11 months old). The comparisons were adjusted using all demographic information and covariates.

259 dyads were screened. Of these 259 dyads, 255 were enrolled: 125 dyads in the control group and 130 dyads in the intervention group. No families refused participation. Three children were born prematurely, and one child was found to have mild to severe developmental delays and thus, were excluded from the sample. At the point of analysis within the intervention group, nine dyads withdrew from the study, two were deceased, and one of a set of twins was removed from analysis to prevent bias occurring from including multiple children within a single household **[Figure 1].**

Measures

ECD Measures. ECD was assessed using the Extended Ages and Stages Questionnaire (EASQ), an adapted version of the Ages and Stages Questionnaire (ASQ) [21], with the same questions presented in continuous format, allowing for pre- and post- score comparison across ages [11, 22]. It screens for developmental risk with three domains: communication (e.g. "If you repeat the sounds your baby makes, does s/he repeat them again after you?"), social/personal development (e.g. "When you reach out your hand to ask for a toy, does baby hand it to you?"), and motor development (e.g. "When your baby is lying face down, can he stretch his arms and lift his chest off the bed or floor?"). Response options are yes, sometimes, and no. A few words on the EASQ were changed for applicability in Sesotho. For instance, on the 4-6 Month item #25.7.10 which reads, "Does your baby make rounds like "ma," "da," "ga," "ca" and "ba"? ", the team removed "ga" and "ca" and added "aaa" and "na" to mimick early sounds in Sesotho. The ASQ is widely used internationally and its psychometric properties among South African and Zambian children are consistent with other populations [23].

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Caregiver Measures. Caregiver engagement was measured using the self-report Parent Ladder [24], an omnibus measure of caregiver engagement designed to measure knowledge, skills and behavior. This scale contains 12 items on a seven-point ordinal scale ranging from 0 (lowest) to 6 (highest) with questions such as "Knowledge of how my child is growing and developing?" and "Ability to identify my child's needs?". The global score was used to measure caregiver engagement. Second, six questions from UNICEF's Multiple Indicator Cluster Survey: for Children Under Five [25] were selected to measure in-home caregiver-child interaction. Questions contain four multiple-response options ("mother", "father", "other", "no one"), and questions such as: "In the past 3 days, did you or any household member engage in any of the following activities with your baby: (1) Read books or looked at a picture books with baby?" and "(2) …sang songs to baby, including lullabies?".

All measures were translated into Sesotho by a certified translator and checked with the ECD nurse fluent in English, then double-checked with the site PI and MCH program manager to ensure meaning was correct. All questions regarding meaning were discussed with a Boston-based ECD researcher.

Caregiver socioeconomic status was measured by educational attainment and household assets. Depressive symptoms were measured using the PHQ-9 [26]. Other covariates such as sex, age, height/length, and weight, were recorded for each child at every data collection point.

Data were collected on tablets and site supervisors attended 10% of data collection events in which they completed the assessment simultaneously and discussed discrepancies with the data collector. Changes were made and the site supervisor recorded discordant

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questions as a percent. Follow-up training was done if 20% or more questions were discordant.

Statistical Analysis

It was determined that 250 participants must be enrolled in order to detect statistical significance of alpha = .05 with a power of .80 for the primary outcome variables. This study enrolled 255 participants. As a preliminary review of the data, correlations between the outcome variables and covariates were inspected using Pearson coefficients. Bivariate analyses then examined individual relationships between independent variables (see above) and outcomes of interest. Based on these preliminary analyses, we identified a consistent pattern of expected associations, indicating acceptable concurrent validity, and did not identify any correlations that were so strong ($r>0.70$) they may be indicative of collinearity in statistical models.

Following preliminary review, the intervention and control groups were compared using univariate and multivariable regression analysis: multivariable linear regression for continuous outcomes such as child EASQ scores, and multivariable logistic regression for binary outcomes, such as caregiving behaviors, documented in the MICS survey. These comparisons examined child development outcomes and caregiving outcomes between groups, adjusting for covariates in order to safeguard against omitted variable bias. Analyses Used STATA's xtreg command to account for autocorrelation and clustering of multiple data points within individuals over time (StataCorp, 2017).

EASQ analysis was stratified by the test age group (7-9 month vs. 10-11 month), and then merged with a dummy variable to represent test type. To ensure appropriateness of intervention and control group comparisons, dyads were compared when infants were within the same age group: namely, 7-11 months old.

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RESULTS

Of the 119 intervention dyads, 100% completed 14 weeks and 83 (70%) completed all 18 weeks. All those completing 14 sessions were included in final analysis, with the exception of one twin who was removed to prevent family bias. In the end, 243 participants had final outcome data.

Of the final sample, mean age of caregiver was 24.8 years and 64% had finished primary school. Mean parity was 2.12 and almost 10% had their last child at home. Slightly more than half (57%) of the infants. Some children showed signs of wasting (15%) and stunting (5%) at 9 months (Table 2).

The control and intervention groups were similar across most demographic characteristics, including immunization completion rates and percentage of clinic-based deliveries. Caregivers in the intervention were slightly more educated and younger, and scored modestly higher on the PHQ-9 depression score at endline, as well as reporting more frequent antenatal care visits. Children of caregivers in the intervention group were slightly younger and had lower anthropomorphic z-scores. Table 2 contains detailed demographic indicators. All covariates were incorporated in final multivariable regression models, regardless of statistical significance, as we determined relevance of covariates a priori based on evidence in child development literature.

[Insert Table 2]

Early Child Development Outcomes

Adjusting for covariates, at endline, children in the intervention group scored higher on EASQ measures across all domains: total score, communication, social, and motor development. Moreover, these results were consistent regardless of whether the age range

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was restricted to 7-9 months at endline, 10-11 months at endline, or pooled, with the one exception being communication in the 7 to 9-month group, for which the intervention group observed non-significantly higher scores (p=0.08). An overview of results, measured in terms of standard deviation (SD) improvements from baseline to endline, is presented in Table 3.

[Insert Table 3]

Caregiver Outcomes

Results also indicated marked improvement on the Parent Ladder in the intervention group compared to the control group. Caregivers in the intervention group were 17 points higher at endline (44%), compared to the control group (δ=1.57, $p<0.001$). Differences remained significant (δ=0.56, $p<0.05$) after adjusting for covariates in the context of multivariate regression.

Similarly, the intervention was associated with greater odds of affirmative responses on all but one MICS items (Table 4). MICS results suggested that caregivers in the intervention group were: 3.7 times more likely to read a book to their child in the past three days, 13.8 times more likely to tell stories, 2.3 times more likely to sing songs, 2.8 times more likely to engage in play, and 2.1 times more likely to name, count, or draw with their child.

[Insert Table 4]

DISCUSSION

We implemented an early childhood development intervention in the Nkau Health Center catchment area of Mohale's Hoek, Lesotho, one of the more rural, remote regions of the country. A total of 130 dyads were enrolled in the intervention over a 6-month period,

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representing the vast majority of new mothers (>90%) attending the clinic. As such, our findings suggest acceptability and feasibility for broad implementation in similar rural settings, including other districts of Lesotho. More importantly, the intervention indicated marked positive impacts on both children and caregivers enrolled.

Children whose caregivers participated in the ECD intervention observed significantly greater improvements in all developmental domains compared to a control group of the same age range. Associated effect sizes were also clinically meaningful—particularly in the older age range of 9 to 11-month-old infants, where group standardized mean differences ranged from 0.30 to 0.50 after adjusting for covariates. We found that caregivers in the intervention group significantly improved their caregiving skills, knowledge and confidence, relative to those in the control group and were more likely engage in interactions with children following receipt of the intervention.

While several studies have shown ECD improvements through caregiver interventions [27-29], most interventions in LMICs have targeted children older than one year [30]. One study, conducted in another rural region of Lesotho still underway, is engaging children ages 1-5 and their caregivers in eight sessions that included HIV and nutritional education and an ECD component involving book sharing to encourage caregiver-child engagement [31]. Likewise, a community-based caregiver intervention by Singla and colleagues (2015) in Uganda resulted in cognitive improvements among children aged 12-36 months [32]. Evidence from high-resource settings indicates that ECD interventions targeted at this first year of child development may be particularly beneficial [17, 33], as the impacts on caregiving behaviors and developmental outcomes are likely to carry forward over the course of childhood. Our study shows this may also be true in settings of poverty within LMICs.

Our study employed a strategic hybrid delivery model. As such, integrating ECD interventions into postnatal care services, as modeled in our study, offers a convenient way

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for caregivers to learn about cognitive development and child stimulation techniques while already in attendance at clinics, at a very early stage in the child's life. Lessons provided at clinics can then be reinforced through VHWs who are operating in community-based settings, further reducing the onus that might otherwise be placed on caregivers to attend educational sessions. Several new studies are enrolling participants using a similar integrated model in other LMICs such as Bangladesh [9].

Even still, ECD interventions in low-resource settings may be forgone because scarce resources limit government capacity to equip clinics and train health care workers [34, 35]. These tradeoffs are inherent in many budgetary decisions, where maternal and child health are underfunded relative to other clinical care domains [36, 37]. Furthermore, rural communities often lack information provided through the internet and other e-learning platforms that might otherwise educate physicians, healthcare professionals and caregivers on how to encourage children's cognitive and physical development [38, 39]. In such context, enhanced caregiver knowledge through ECD interventions based in the community may be introduced at low cost by building off of existing primary health care infrastructure. The framework outlined in this study offers a successful illustration of this.

A few study limitations should be mentioned. There is a potential for unmeasured differences between the intervention and control groups, which could account for some level of difference in ECD outcomes. We attempted to mitigate this possibility by gathering a wide range of covariates. Likewise, magnitude of the observed impact of the intervention was sizable, making a Type 1 error relatively unlikely.

A third consideration is participant response bias. Measures were dependent on self-reports of caregivers and repeated administration of tests. It is possible, for example, that those in the intervention group believed survey administrators wanted to hear that caregiving behavior and ECD outcomes improved over time. This could overestimate the impact of the

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intervention on ECD. The fact that this intervention was adapted from a mixed urban and rural setting in Peru may suggest the external validity of the program. However, its use in other African settings would depend on the similarity of the culture and setting and the careful adaptation of the content.

Further research calls on qualitative data such as focus groups to understand what aspects of the intervention were useful and how the caregivers believed their practices changed in response to the sessions.

CONCLUSIONS

This study demonstrated significant effects of an ECD intervention on early child development, as well as caregiver knowledge and skills. The intervention was implemented with few resources by leveraging existing human resources and health system infrastructure. Based on this, we are hopeful to scale the intervention more broadly in districts throughout rural Lesotho.

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Table 1a. Group Session Activity Agendas

Activity	Time (minutes)	Name	Description
Activity 1	10	Program introductions Introductions Ice breaker	Facilitator introduces the program Dyad introduction In a box, collect items that symbolize ideas and activities: toys, hygiene item, object that can be used as a toy, nursing item, info on vaccines, picture of mom playing with baby, picture of baby clapping, etc. Each participant picks out an object and they describe how they think it relates to the overall topic of the project. This will allow introduction of the project content and allow caregivers to express their understanding of pertinent project items.
Activity 2	5	Group norms	Confidentiality, importance of learning from each other, agenda for the day, etc…
Activity 3	5	Tips	Tip related to child health and hygiene: 1) washing hands; 2) skin care for the baby (umbilical cord care); 3) perinatal care/ caring for the body after birth Provide a handout with information.
Activity 4	30	"Serve and return" concepts and practice	Play and Communication Activities: refer to activity guide Free play in small groups: Caregivers can choose the game and groups as small as 2 dyads practice "serve and return". Facilitator and assistant give suggestions/ congratulations to each group; flip charts can give ideas if needed.
Activity 5	30	Home experience /Social support and problem solving	Each mom shares experiences or ideas of stimulation and playing games in the home. If not first session, practice since the last session Open conversation: Reflect on and offer examples of barriers to stimulation in the home and/or frustrations related to their child's development. Reach out to the group to brainstorm solutions and ideas on how to better integrate lessons learned from the group to daily life
Activity 6	15	Close	Reflection on the session and suggestions and tips shared between caregivers. The facilitator and assistant will encourage caregivers' enthusiasm. End with the same song every session to allow for another exercise to engage the caregiver and infant.

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Table 1b. Session Activity Agendas

Activity	Time (minutes)	Name	Description
Activity 1	5	MVHW Introduction Family Introductions	I would like to spend some time understanding how the family is getting on with the play and communication activities recommended from the group sessions at the clinic on early childhood development.
Activity 2	30	Home experience and problem solving	Talk to mom about experiences of stimulation and playing games in the home. Ask about progress since group session. Ask to see an example of an activity that the caregiver does with the child. Ask caregiver to reflect on and offer examples of barriers to stimulation in the home and/or frustrations related to their child's development *Remember to praise and encourage caregiver and reassure caregiver.
Activity 3	30	"Serve and return" concepts and practice	Play and Communication Activities: refer to individual session activity guide With mom and any additional family member pick one play activity and one communication activity per visit to observe with caregiver.
Activity 4	15	Close	Ask caregiver if they have any questions and/or concerns Reiterate concepts and importance of play and communication activities Plan for next visit

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Table 2: Baseline Characteristics of Intervention and Control Groups

Demographic Measures: Binary	Control Group N (%)	Intervention Group N (%)
Caregiver		
Female	124 (99%)	117 (99%)
Primary school complete	71 (57%)	84 (71%)*
Birth at home	10 (8%)	13 (11%)
Infant		
Female	73 (58%)	65 (55%)
Evidence of wasting	14 (11%)	22 (18%)*
Evidence of stunting	5 (4%)	6 (5%)
Underweight	7 (6%)	10 (8%)*
Fully Immunized at 9 months	125 (100%)	112 (95%)
Demographic Measures: Continuous	**Mean (SD)**	**Mean (SD)**
Caregiver		
Age (years)	26.01 (7.18)	23.50 (6.32)*
Parity	2.18 (1.56)	2.06 (1.50)
Gravida	2.27 (1.64)	2.21 (1.68)
Pregnancy weeks at birth	38.82 (1.72)	38.79 (1.50)
ANC visits	3.03 (1.16)	3.35 (1.04)*
Household members	5.92 (2.12)	5.75 (2.19)
Depression score	2.98 (3.08)	5.18 (5.18)*
Infant		
Age (months)	9.40 (0.32)	9.30 (0.31)*
Weight for height	-0.44 (1.45)	-1.03 (1.22)*
Length for age	0.75 (2.08)	0.69 (1.63)*
Weight for age	0.12 (1.22)	-0.60 (1.02)*

** Difference between control and intervention groups p<.05*

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Table 3: Early Child Development Outcomes on EASQ – Difference by Group

EASQ Category	Mean Difference	95% CI	Standardized Coefficient	95% CI	Adj R^2	Obs.
Communication						
EASQ 7-9 month	0.11	0.03 - 0.18	0.09	-0.03 - 0.14	0.08	184
EASQ 10-11 month	0.50*	0.23 – 0.76	0.34*	0.14 - 0.62	0.41	59
Combined	0.27*	0.00 - 0.18	0.21*	0.07 - 0.26	0.22	243
Social Development						
EASQ 7-9 month	0.11*	0.03 - 0.19	0.15*	0.01 - 0.17	0.07	184
EASQ 10-11 month	0.49*	0.26 - 0.73	0.42*	0.20 - 0.63	0.42	59
Combined	0.27 *	0.19 - 0.36	0.27*	0.11 - 0.28	0.26	243
Motor Development						
EASQ 7-9 month	0.14*	0.07 - 0.21	0.26*	0.07 - 0.24	0.05	184
EASQ 10-11 month	0.46*	0.20 - 0.71	0.46*	0.23 - 0.75	0.19	59
Combined	0.22*	0.16 - 0.32	0.33*	0.14 - 0.31	0.12	243
Total Score						
EASQ 7-9 month	0.12*	0.06 - 0.18	0.21*	0.03 - 0.17	0.06	184
EASQ 10-11 month	0.48*	0.30 - 0.66	0.51*	0.26 - 0.60	0.48	59
Combined	0.24*	0.20 - 0.33	0.32*	0.13 - 0.27	0.26	243

*Notes: *p<0.05. Adjusted multivariable regression included child sex and age, as well as caregiver education, socioeconomic status, and fixed effects for research staff members conducting the assessment. "95% CI stands for 95% Confidence Interval.*

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Table 4. Caregiver Engagement – Difference by Group

MICS Measure	Adj. OR	95% CI	Pseudo R^2
Read book	3.77*	1.94 - 7.29	0.14
Told stories	13.75*	6.32 – 29.90	0.27
Sang songs	2.29 *	1.09 - 4.83	0.08
Took outside	1.49	0.76 – 2.90	0.05
Actively played	2.83	0.86 - 9.21	0.12
Named/counted	2.05*	1.24 - 3.71	0.07

*Notes: *p<0.05. Adjusted multivariable regression included child sex and age, as well as caregiver education, socioeconomic status, and fixed effects for research staff members conducting the assessment. "Adj. OR" stands for "Adjusted Odds Ratio" and "95% CI" stands for "95% Confidence Interval of the Adjusted Odds Ratio".*

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Figure 1. Study Flow Diagram

Notes: The control group comprised caregiver-infant dyads in which infants were 7-11 months-old in May-July 2017, the recruitment period. Caregiver-infant dyads in the control group were assessed immediately upon study enrolment only. The intervention group comprised caregiver-infant dyads in which infants were 0-2 months in May-July 2017. Caregiver-infant dyads in the intervention group were assessed three times (baseline, midterm, final assessment), with baseline assessment conducted immediately upon study enrollment and final assessment conducted an average of eight months later, when infants were 7-11 months-old.

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Contributorship statement

All authors reviewed manuscript drafts and consented to the final submitted version.

Melino Ndayizigiye is the Principal Investigator for this study. He is responsible for writing the grant, securing funding, representing the study at international conferences, and interfacing with the ethics committee and US-based investigators. He oversaw on-site study activities and managed Lesotho site staff.

McBain, Ryan K. is the US-based study lead who joined in the analysis phase. He was in charge of coordinating co-investigators, supervising data analysis, and co-writing the manuscript.

Collin Whelley conducted all data management and analysis with the help of AM.

Rorisang Lerotholi, the study coordinator, reviewed translated assessment and intervention materials, translated during village health worker trainings, consulted on adaptations, conducted fidelity checks on interventions, and collected data for analysis.

Joalane Mabathoana, the then Maternal and Child Health Program Manager at Partners In Health, Lesotho managed the study coordinator and participated in adaptation of materials and training of village health workers.

Carmona, Merida, was in charge of donor compliance and study design.

Curtain, Joe developed the study design with Ms. Carmona.

Birru, Ermyas developed data collection instruments, consulted on data components of the study design, analysis and review of the manuscript.

Sara Stulac is a pediatrician and co-investigator on this grant with experience working in Lesotho. She delivered expertise in the field of early child development and pediatrics.

Ann C. Miller is the epidemiologist responsible for data analysis for the CASITA project. She provided analytical for this study guidance to CW, specifically for the EASQ, including coding for score standardization.

Sonya S. Shin is the senior researcher for the CASITA project and provided high level mentorship to AKN in the adaptation of the study intervention and training of village health workers.

Nancy Rumaldo is the site leader of the CASITA project and provided field-level consultation during the adaptation and training in Lesotho.

Mukherjee, Joia was the senior clinician in charge of overseeing the clinical components of the study.

Adrianne Katrina Nelson, Principal Investigator of the pilot CASITA study, facilitated intervention and measurement tool translation and adaptation for this study. She traveled to

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Lesotho to train MJ, the study coordinator, and the village health workers in the intervention. She co-wrote the manuscript and was in charge of submission and correspondence.

Competing interests

Authors report no competing interests.

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Data sharing statement

Extra data is available by emailing Collin Whelley at collinwhelley@gmail.com

Ethics statement

The study was reviewed and approved by the Lesotho National Ethics Committee approval reference #ID51-2017.

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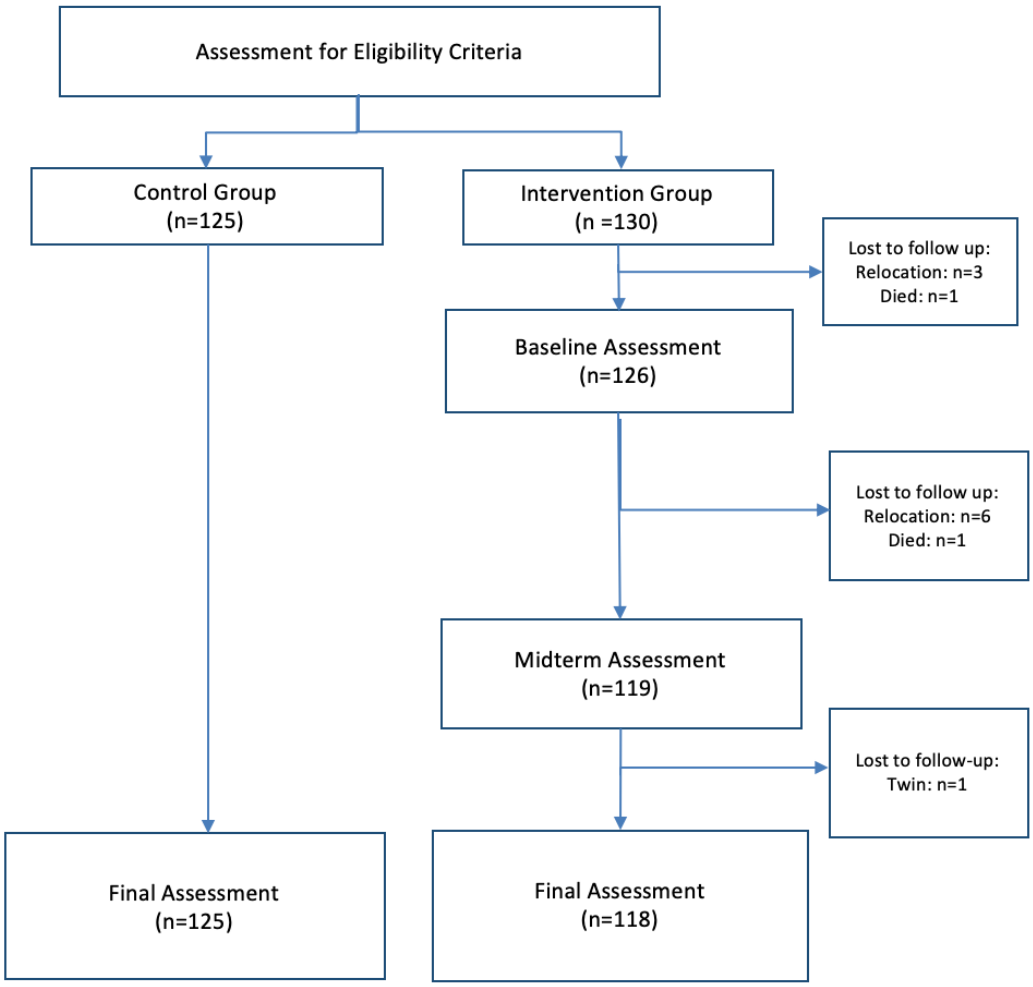
Figure 1. Study Flow Diagram



Notes: The control group comprised caregiver-infant dyads in which infants were 7-11 months-old in May-July 2017, the recruitment period. Caregiver-infant dyads in the control group were assessed immediately upon study enrolment only. The intervention group comprised caregiver-infant dyads in which infants were 0-2 months in May-July 2017. Caregiver-infant dyads in the intervention group were assessed three times (baseline, midterm, final assessment), with baseline assessment conducted immediately upon study enrollment and final assessment conducted seven months later, when infants were 7-11 months-old.

STROBE Statement—Checklist of items that should be included in reports of ***case-control studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7-8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls	9
		(*b*) For matched studies, give matching criteria and the number of controls per case	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	11-12
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	11-12
Bias	9	Describe any efforts to address potential sources of bias	13
Study size	10	Explain how the study size was arrived at	13
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	11-12
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	13
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	13
		(*d*) If applicable, explain how matching of cases and controls was addressed	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10
		(b) Give reasons for non-participation at each stage	10
		(c) Consider use of a flow diagram	22
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	19
		(b) Indicate number of participants with missing data for each variable of interest	14
Outcome data	15*	Report numbers in each exposure category, or summary measures of exposure	14

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Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	14-15, Table 2
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	17-18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17
Generalisability	21	Discuss the generalisability (external validity) of the study results	18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	13

*Give information separately for cases and controls.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

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