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# The effect of a parental mHealth resource on language outcomes in 4- to 5-year-old children

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**Background:** The use of mobile health (mHealth) technology is rapidly expanding in healthcare worldwide. mHealth tools may provide parents with access to resources essential for promoting language development.

**Aim:** The current study aimed to determine how an mHealth parental resource influenced 42 preschool children's (4.0–5.11 months old) language abilities after a 17-week intervention period.

**Setting:** Participants were identified from six early childhood development (ECD) centres from a low-income community in Tshwane, South Africa.

**Method:** A randomised controlled trial (RCT), pre-test post-test research design was employed to determine whether an mHealth parental resource influenced 42 preschool children's (4.0–5.11 months old) language abilities after a 17-week intervention period. Data were collected using the language subtests of a South African standardised protocol, the Emergent Literacy and Language Assessment Protocol (ELLA).

**Results:** The parental mHealth application targeting language stimulation did not significantly improve the experimental group's language outcomes when compared with the control group because most of the parents ($n$ = 27) used the application for less than 20% of the active days.

**Conclusion:** Providing parents with more support with mobile resources may lead to improved usage of the application.

**Keywords:** parental resource; mHealth; language development; preschool children; early child development.

## Introduction

Early language development plays an essential role in a child's life trajectory (McClure et al. 2018). Language abilities upon school entry are the best predictor of later reading abilities, academic progress and vocational success (Spilt, Koomen & Harrison 2015; Zauche et al. 2016). Resources focused on language development should use creative and practical interventions that equip and encourage parents to engage in stimulating exchanges with their children (McClure et al. 2018). Smart devices have the potential to provide parents from various socio-economic backgrounds with access to digital resources that can promote language stimulating interactions with their young children (McClure et al. 2018; Independent Communications Authority of South Africa [ICASA] 2020). Mobile health (mHealth) could provide vulnerable members of society with increased access to free resources that can support children's development during early childhood.

Young children from lower middle-income countries (LMICs), such as South Africa, are at a higher risk for developmental delay than their peers in high-income countries (Grantham-McGregor et al. 2007). High prevalence rates for poor development can be because of the culmination of risk factors, including inadequate health care, malnutrition, poverty and limited stimulation at home (Grantham-McGregor et al. 2007). Most (65.4%) of the South African children, aged from birth to 17 years, grow up in households of low socio-economic status (SES) where nutrition, health and safety are often parents' immediate priorities; early developmental stimulation may be prioritised to a lesser extent (Hall et al. 2018; ed. Keller 2014).

Developmental delays, especially delays in language acquisition and acceptable proficient usage levels in accordance with age, are typically identified late amongst children from low

**Note:** Special Collection: Early Childhood Development in Theory and Practice.

socio-economic settings in South Africa (Kathard et al. 2011). As children grow older, untreated developmental delays have a cascading effect because early delays later impact academic performance, including literacy abilities. Later still, individuals' earning potential can be impeded because of an ability to participate fully in society. This, in turn, increases the risk of intergenerational poverty (Grantham-McGregor et al. 2007). The Progress in International Reading Literacy Study (PIRLS) measured literacy levels between 2011 and 2016 and found that 78% of South African grade four learners were illiterate (Howie et al. 2017). Factors associated with better PIRLS outcomes were included when parents read stories, talked and sang to their children before they started formal schooling (Howie et al. 2017).

Interventions in response to the poor PIRLS results have predominantly focused on school-going populations and not on younger children, for example, the Early Grade Reading Study (EGRS), which is literacy focused. Both the EGRS and PIRLS, however, highlight parental involvement in children's development as a determining factor for children's learning outcomes, especially language acquisition (Department of Education [DoE] 2017; Howie et al. 2017). To counter the poor literacy performance of school-aged children, a solution is needed to help them develop better early language and later literacy abilities. Early parental stimulation in the home learning environment (HLE) has been shown to predict children's language and academic skills (Barnes & Puccioni 2017).

Evidence-based programmes that promote child development often incorporate parent training, as parental involvement has been shown to be more effective than clinician-directed intervention (DeVeney, Hagaman & Bjornsen 2017; Roberts & Kaiser 2011; Shah et al. 2016). Parents are best placed to facilitate the acquisition of early language skills as early home language development is shaped by interactions in their day-to-day environments (Owens 2012; Schmerse et al. 2018). A strong home language is the foundation to support the development of second language acquisition (Suskind et al. 2016). In LMICs, the language of learning and teaching (LoLT) often differs from the home language, and many children enter formal schooling with their home language already delayed because of exposure to risk factors (Van Staden, Bosker & Bergbauer 2016). This may result in children not reaching their optimal academic functioning in either language.

Increasing the amount of parent-child conversational exchanges through activities, such as shared book reading, has a positive impact on young children's underlying cognitive and language development regardless of SES (Nelson et al. 2019; Romeo et al. 2018; Vally et al. 2015). Apart from limited resources, there is often little to no culture of book sharing in low-income settings but rather a culture of storytelling (Mdlalose-Dyantyi 2019; Vally et al. 2015). Increasing parents' access to easy-to-use language development resources that encourage dialogic book sharing is a preventative or ameliorative action to improve later learning outcomes (Vally et al. 2015). Over the past two decades, there has been increased interest in evidence-based mHealth as an innovative approach to early learning (Beddington et al. 2008; Kyle et al. 2013).

According to (ICASA 2020), 91.2% of South Africans own a smartphone. More South Africans have access to smartphones than ever before (ICASA 2020), although parents in low socio-economic settings still have limited access to mHealth resources, especially those that are available in their home language. Additionally, parents may require training when using available resources, like mHealth applications (Eslick et al. 2018). Educator-led mHealth literacy awareness campaigns have been shown to improve children's language and literacy outcomes (Smith & Hugow 2017). Globally, however, there is limited evidence of the effect that parent-led mHealth has on early language and literacy development amongst young children. (McClure et al. 2018). Studies such as READY4K used text messaging to help parents support their pre-schoolers' general development and resulted in pre-schoolers' higher emergent literacy scores (York, Loeb & Doss 2018). mHealth resources have potential as a tool to shape parental behaviours that promote language development amongst children, but the use of mHealth tools on children's language abilities requires further investigation (McClure et al. 2018).

There are several evidence-based language stimulation practices that rely on parent implementation, yet little is known about the use of mobile technology for parent-implemented language stimulation in young children (Cologon, Wicks & Salvador 2017; McClure et al. 2018). For optimal early development, parents need to support their children's early language development (Formeset 2008) as this results in improved academic outcomes at a later stage (Weisleder & Fernald 2013). Therefore, the question is posed: what is the effect of a parental mHealth resource targeting language skill in 4-to 5-year-old children?

# Research method and design

## Study design

Elizabeth le Roux (main author) and Cornelia Scheepers (main author of a seperate paper), used the ELLA protocol where the first author focused on the participants' language abilities and the latter focused on the literacy abilities (Scheepers et al. 2021). A randomised controlled trial (RCT) design was used to determine the effect of a parent mHealth resource targeting language skills, specifically vocabulary word definitions, fictional narratives, mean length utterance (MLU) and type token ratio (TTR) as part of the expressive language, in 4- to 5-year-old children.

## Setting

Participants were identified from six Early Childhood Development (ECD) centres situated in a low-income community in Tshwane, South Africa. Early Childhood Development centres are defined as care centres where pre-school children are looked after and where their physical, social, cognitive and emotional skills are developed (DoE 2001).

## Study population and sampling strategy

Participating parents had to be older than 18 years, have a grade 5 or above conversational English skills, own an Android smartphone and have children aged between 4.0 and 5.11 year old at the beginning of data collection. Children were excluded if developmental speech, language or hearing concerns were identified. After the inclusion screening, 82 parent-child dyads (28 male, 54 female children) met the inclusion criteria.

Participants were age-matched (4.00–5.00 years and 5.00–6.00 years) and gender-matched into an experimental group consisting of 42 participants and a control group with 40 participants. The mean age of the experimental and the control groups was 57.45 months (SD = 5.86) and 58.95 months (SD = 6.21), respectively, where SD denotes the standard deviation. Most of the children were multilingual, which is typical in South Africa (Olivier 2009). English was the most common first language of the total sample (65.9%, $n$ = 82). Other dominant languages included Northern Sotho (13.4%), Setswana (4.9%), Sesotho (3.7%), isiZulu (3.7%) and isiXhosa (2.4%). Most parents had a tertiary qualification (72.6%, $n$ = 119) and were employed (77.5%, $n$ = 127). Employment and education are significant predictors of better language outcomes (Lecheile et al. 2020; Vernon-Feagans et al. 2012).

## Intervention

CareUp is a recent interactive smartphone application that focuses on improving language and literacy through parent involvement (The Reach Trust 2018). The application is based on the core principles of Wordworks, a validated and widely used programme, which aims to include all children, regardless of their language capabilities or home circumstances, in their campaign to increase literacy and language development (Smith & Hugow 2017). This resource is aligned with the National Curriculum of Education (Republic of South Africa. Department of Basic Education2010) and was designed in South Africa for South African families (The Reach Trust 2018). Once CareUp is downloaded on users' mobile phones, there are no additional running costs. The application is available in Afrikaans, English, isiXhosa and isiZulu. Parents participating in this study could select their language of preference. They received three weekly push notifications with instructions and activities to help stimulate early language in the home context. CareUp provides parents with culturally appropriate resources such as stories for parents to read to young children during shared book reading. The application developers have observed positive responses from parents, but independent testing, specifically of children's outcomes, is required to validate the CareUp application's effect on children's language and literacy abilities.

## Materials and apparatus

All data were collected by the two researchers involved who were speech-language pathology master's students. These students were qualified speech-language therapists registered with the Health Professions Council of South Africa.

## Screening measures for inclusion

The Parents Evaluation Developmental Status (PEDS) Tools (Glascoe & Robertshaw 2009) were used as a developmental screener based on the parental concern of children's speech, language and hearing abilities. Children were excluded if the parental concern of speech, language and hearing-related skills was identified using the developmental screener. This was performed to control confounding factors such as possible hearing impairment and communication delays, as these factors may have made between-group comparisons challenging. Children were referred to a speech-language pathologist and/or audiologist if necessary.

The hearScreen application (Swanepoel et al. 2014), which is a validated tool for preschool hearing screening programmes, was used to screen the children's hearing (Yousuf Hussein et al. 2018). The hearScreen application presents a test frequency of 1, 2 and 4 kHz bilaterally at a screening intensity of 25 dB through calibrated headphones (Yousuf Hussein et al. 2018). If they failed the screening test, they were excluded from the study and referred to an audiologist.

## Biographical questionnaire

A researcher-developed questionnaire was completed by parents regarding biographical information and children's prenatal and birth, developmental and educational history.

## Language assessment

Language data were collected using subtests of the adapted Emergent Literacy and Language Assessment Protocol (ELLA) (Willenberg 2007). This protocol is a comprehensive test battery developed in South Africa and used to assess the language and literacy abilities of pre-schoolers (Olivier 2009; Willenberg 2007). The ELLA protocol has been used previously in published studies and is deemed reliable (Olivier 2009; Sharma, Vallabh & van Der Merwe 2013; Willenberg 2007). The protocol can be divided into three main assessment areas, namely orientation to print, knowledge of phonology and language. The language subsets, which were the focus of this study, were evaluated: Vocabulary was assessed using the Peabody Picture Vocabulary Test Fourth Edition (PPVT-4) (Dunn & Dunn 2007), word definitions were tested from the Test of Preschool Early Literacy (TOPEL) (Lonigan et al. 2007) and fictional narratives were evaluated using the Narrative Assessment Protocol (NAP) (Justice et al. 2010). The MLU and TTR were also calculated as part of the expressive language vocabulary subtest, which were elicited using the School-Age Language Assessment Measures (SLAM) (Crowley & Baigorri 2015). The ELLA protocol subsets were administered in a 1-h session at the ECD centres. Raw scores were used for all pre- and post-test comparisons as the measures included in the assessment tools were not standardised for the South African population.

### Data collection

A pilot study was conducted to provide the researcher with information on the ELLA protocol assessment procedures. The protocol was deemed valid and reliable, and no changes were required. The study had four phases. In the first phase, meetings were arranged with prospective parents at the ECD centres where study information was provided, informed consent was obtained and screening measures determined the inclusion eligibility. Appropriate referrals were made if parental concern regarding language, speech or hearing was identified. During phase 2 of the study, the included 82 participants were assessed at the ECD centres using the subsets of the ELLA protocol. The ELLA protocol took approximately 1 h to administer with each participant. The parents completed the biographical questionnaire and children were divided into groups according to their age and gender. The researchers were blinded as to who formed part of the respective experimental and control groups to reduce researchers' bias. Parents from the experimental group then received the CareUp application and a brief explanation regarding the application. Each parent received a participant number that they used as their username in the application; thus, no names were shared on the mobile application profile to allow for confidentiality.

During the third phase, the parents in the experimental group followed the CareUp programme for 17 weeks with their children with no prescribed minimum frequency; thereafter, the ELLA was used to reassess all participants' language abilities (phase 4). The developers of the application downloaded data from the CareUp application, including how often the parents had accessed the application over the intervention period. After post-test assessments, the control group was offered the CareUp application. Parents in the control and experimental groups received feedback regarding their children's language results. After the post-test, the researcher contacted 13 parents from the experimental group that had varying degrees of usage, from the highest, middle and lowest usage groups, to ask them questions regarding their usage and experiences with the CareUp application.

### Data analysis

Descriptive statistics were used to analyse the biographical questionnaire responses. The ELLA protocol does not provide an overall score for language; however, the subtests provide individual results. Assessment outcomes for each subtest were analysed individually using the Statistical Package for the Social Sciences (SPSS) software package version 25.0. To test for normality, the Kolmogorov-Smirnov and Shapiro-Wilk tests were used along with their corresponding *p*-values (Field 2018). If the *p*-value was greater than 0.05, the underlying distribution of the data is normally distributed, and parametric tests were used. On the other hand, if the *p*-value was less than 0.05, the underlying distribution of the data differs from normality, and nonparametric tests were used. It was found that most of the variables were not normally distributed. Thus, the Mann-Whitney (MW) test and Wilcoxon signed-rank (WSR) nonparametric tests were used. The MW test (Mann & Whitney 1947) was used to detect differences between the experimental and control groups from pre- to post-test, respectively. The WSR test (Wilcoxon 1945) was used for the pre- and post-test to indicate differences within the control group and within the experimental group, respectively, for continuous data. An extreme value analysis was performed to identify and, ultimately, remove outliers because outliers can dramatically reduce the power of significance tests (Field 2018). Outliers were identified in a pre-test vocabulary subtest, and five values were removed from the control group and seven from the experimental group. For the post-test vocabulary, there was only one outlier, which was removed. Thematic analysis was used to analyse the parental feedback on CareUp application. This is used for identifying themes within qualitative data (Maguire & Delahunt 2017).

### Ethical considerations

Ethical clearance was obtained from Institutional research board (GW20190118HS).

## Results

The baseline assessments showed no statistically significant between-group differences in vocabulary ($p = 0.073$), word definitions ($p = 0.065$), MLU ($p = 0.218$), TTR ($p = 0.855$) and fictional narrative analysis ($p > 0.05$) (Table 1). The post-test assessments identified a significant between-group difference in PPVT-4 vocabulary ($p = 0.044$) and the TOPEL definitional vocabulary ($p = 0.023$), where the control group ($m = 53.95$) had a higher mean when compared to the experimental group ($m = 49.74$), where $m$ denotes the mean. There were no other statistically significant between-group differences at post-test ($p > 0.05$). Three statistically significant within-group improvements were identified at post-test, namely the vocabulary scores of the control group ($p < 0.001$) and the experimental group ($p < 0.001$), the MLU of the control group ($p = 0.005$) and both the control and experimental groups showed significant within-group improvement in six NAP subsections ($p > 0.05$) (Table 1). The language testing ceiling effect was not a consideration in the current study as none of the children reached maximum response for any test included in the ELLA protocol.

Most of the parents chose to use the application in English (90.5%), whilst two of the parents chose isiXhosa (4.8%), and two parents selected Afrikaans (4.8%). The average number of active days ($m = 24$) indicated parents' usage of the CareUp from the day of download to the post-test assessment in percentage (Figure 1). An active day is recorded when a parent either opens an activity or a story, and this tracks how often the parent used the application. Almost two-third (64.3%) of the parents used the application less than 20% of the active days. Only 12 out of the 42 parents (28.6%) in the experimental group used the application for more than 50% of the intervention period.

**TABLE 1:** Between- and within-group comparisons for the Emergent Literacy and Language Assessment Protocol subtest results.

| ELLA Subtests | Control group ($n$ = 40) | | | | | | Experimental group ($n$ = 42) | | | | | | Between- group pre-test | | Between- group post-test | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pre-test | | Post-test | | Within-group | | Pre-test | | Post-test | | Within-group | | | | | |
| | Mean | SD | Mean | SD | $p$ | WSR-value | Mean | SD | Mean | SD | $p$ | WSR-value | $p$ | MW-value | $p$ | MW-value |
| Vocabulary | 48.47 | 5.46 | 52.53 | 5.37 | 0.000* | -5.065 | 45.69 | 6.09 | 49.66 | 5.54 | 0.000* | -4.358 | 0.073 | 597.5 | 0.044* | 613.0 |
| Word definitions | 42.25 | 17.59 | 53.95 | 11.77 | 0.000* | -5.514 | 37.26 | 15.25 | 49.74 | 10.95 | 0.000* | -5.503 | 0.065 | 641.0 | 0.023* | 596.0 |
| MLU | 0.75 | 0.50 | 1.02 | 0.24 | 0.005* | -2.792 | 0.86 | 0.46 | 1.07 | 0.03 | 0.636 | -0.474 | 0.218 | 708.5 | 0.744 | 805.0 |
| TTR | 0.36 | 0.25 | 0.43 | 0.12 | 0.368 | -0.889 | 0.38 | 0.21 | 0.47 | 0.08 | 0.288 | -1.063 | 0.855 | 820.5 | 0.403 | 750.0 |
| Fictional narratives: Complex sentence | 2.53 | 1.58 | 3.90 | 1.82 | 0.000* | -3.607 | 2.26 | 1.98 | 3.83 | 1.75 | 0.000* | -3.544 | 0.407 | 752.0 | 0.759 | 807.5 |
| Fictional narratives: Negative sentence | 0.83 | 1.13 | 1.88 | 1.11 | 0.000* | -3.626 | 0.71 | 0.99 | 1.62 | 1.23 | 0.000* | -4.219 | 0.717 | 804.5 | 0.241 | 719.0 |
| Fictional narratives: Elaborated noun phrase | 0.73 | 2.01 | 1.18 | 2.25 | 0.179 | -1.342 | 0.26 | 0.73 | 0.45 | 1.04 | 0.332 | -0.970 | 0.160 | 733.0 | 0.338 | 756.0 |
| Fictional narratives: Prepositional phase | 1.88 | 1.60 | 3.18 | 2.33 | 0.001* | -3.397 | 1.79 | 1.99 | 2.81 | 1.64 | 0.011* | -2.531 | 0.498 | 769.0 | 0.767 | 808.5 |
| Fictional narratives: Modifiers | 0.00 | 0.00 | 0.05 | 0.22 | 0.157 | -1.414 | 0.02 | 0.15 | 0.05 | 0.31 | 0.655 | -0.447 | 0.329 | 820.0 | 0.549 | 819.0 |
| Fictional narratives: Pluralised noun | 0.70 | 0.94 | 1.30 | 1.38 | 0.039* | -2.063 | 0.86 | 1.09 | 0.98 | 1.33 | 0.615 | -0.503 | 0.563 | 783.0 | 0.117 | 680.0 |
| Fictional narratives: Tier-two noun | 0.10 | 0.30 | 0.025 | 0.16 | 0.180 | -1.342 | 0.05 | 0.22 | 0.10 | 0.62 | 1.000 | 0.000 | 0.366 | 796.0 | 0.986 | 839.5 |
| Fictional narratives: Auxiliary verb and main verb | 2.15 | 1.73 | 2.625 | 2.16 | 0.332 | -0.971 | 2.38 | 2.00 | 3.31 | 2.41 | 0.020* | -2.324 | 0.723 | 802.5 | 0.187 | 699.5 |
| Fictional narratives: be' verb | 2.85 | 2.47 | 4.28 | 2.86 | 0.005* | -2.793 | 2.98 | 2.36 | 3.33 | 2.41 | 0.252 | -1.146 | 0.725 | 802.5 | 0.168 | 693.0 |
| Fictional narratives: Irregular past tense verb | 2.2 | 2.34 | 3.48 | 3.16 | 0.027* | -2.216 | 1.95 | 1.97 | 2.98 | 2.83 | 0.048* | -1.977 | 0.744 | 805.5 | 0.491 | 766.5 |
| Fictional narratives: Regular past tense verb | 1.43 | 1.72 | 1.80 | 1.59 | 0.137 | -1.489 | 0.81 | 1.47 | 1.43 | 1.68 | 0.048* | -1.980 | 0.035* | 631.0 | 0.159 | 692.5 |
| Fictional narratives: Tier-two verb | 0.03 | 0.16 | 0.10 | 0.30 | 0.083 | -1.732 | 0.00 | 0.00 | 0.02 | 0.15 | 0.317 | -1.000 | 0.306 | 819.0 | 0.152 | 776.0 |

ELLA, Emergent Literacy and Language Assessment Protocol; MLU, Mean Length Utterance; MW, Mann-Whitney; TTR, Type Token Ratio; WSR, Wilcoxon signed-rank.
*, $p < 0.05$ statistically significant.

The average number of activities opened for at least 10 s was 23.50, and the number of stories opened for at least 15 s was on an average 6.83. The number of stories which were opened for at least 10 and 15 s did not show a significant difference in 4 to 5-year old children's language development. The short period of opening stories for at least 10 and 15 s was selected as the lowest limit of opening a story to show an indication of parents' interest in the resources available on the application. Almost all (95.2%) of the parents did not disable their push notifications from the application, but the less the parents used the application, the fewer reminders they received. Thus, if the CareUp application is not opened regularly, the application does not send activity reminders to the parents.

Upon an analysis of the mHealth application usage, thereof, suggested no association between the active days and the outcomes of pre-schoolers in the experimental group in this study. However, because less than one-third of the parents actively used the application, it would be beneficial to conduct a follow-up study, where more parents actively use the application for a more accurate comparison between the parents who used it and those who did not use it.

To gather parental feedback regarding the CareUp application, 13 parents were divided into three groups according to their activity level on the application, namely, four parents in the highest group (36% – 87%), five from the middle group (12% – 28%) and four from the lowest group (1% – 11%). Eleven out of the 13 parents (84.6%) reported that they had used the application and liked the stories and activities. Seven parents (53.8%) reported that they had not experienced any challenges with the application, and that they will use the application in the future. Two parents (15.4%) reported that they did not use the application regularly because they either did not have

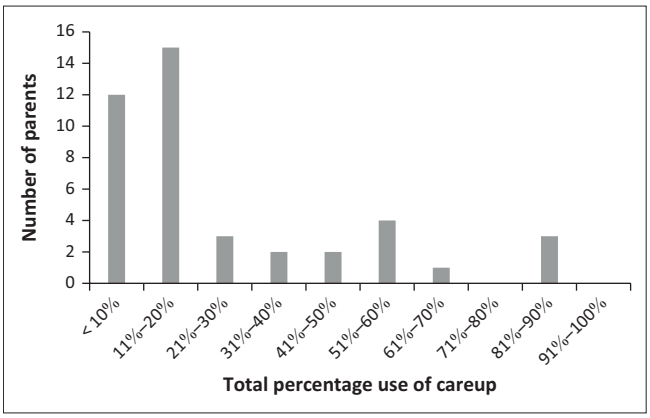


**FIGURE 1:** Percentage of parents' active days CareUp usage ($n$ = 42).

enough data or did not like technology. They formed part of the middle group (12% – 28% usage over the active days). One of the parents also reported that they liked the application as it provided them guidelines on how to stimulate language development. The challenges that hindered use were a broken phone ($n$ = 1), a lost phone ($n$ = 1) and phone storage space ($n$ = 1). One parent also reported that she forgot that she had the application on her phone.

## Discussion

Seventeen weeks of exposure to a parental mHealth application targeting language stimulation did not significantly improve the experimental group's language scores when compared with the control group. A probable confounding variable was certainly the parents' use of the applications. Most of the parents (64%) used the application less than 20% of the active days between the pre- and post-test. The limited usage of the application is contrary to a similar study completed with the CareUp application over 15 weeks in a low-income setting in South Africa (Roberts & Spencer-Smith 2017). In that study, two-thirds of the parents accessed the CareUp application at least three times per week. A difference between the studies was that the latter presented an activation workshop with the parents before the intervention period to orientate the parents to the application (Roberts & Spencer-Smith 2017), whereas the current study only provided a brief explanation. Activation workshops may, therefore, provide the parents with the support and guidance they need when accessing language stimulation resources (Eslick et al. 2018). Previous studies, however, focused on the uptake of the application by parents and ECD practitioners (Roberts & Spencer-Smith 2017). No study prior to this study has assessed children's language abilities before or after exposure to the CareUP application.

Application use has also been shown to increase when consistent text message reminders are provided in comparison with push notification reminders. Text messages have successfully enhanced parental use of activities to promote language and development (McClure et al. 2018; York et al. 2018). One of the parents' feedbacks regarding CareUp was that she forgot that she had the application on her phone. Providing parents with more consistent support may lead to improved and consistent usage of applications. Engaging elements like gamification have also been shown to improve adults' interaction with resource-based applications (McClure et al. 2018). Gamification encourages consistent use of applications by applying game-design elements (McClure et al. 2018). The CareUp application has a progress section that shows the different activities completed; however, after completing activities, parents do not earn any badges or rewards. The addition of a reward or badge on completion of activities to increase application use should be investigated.

Between-group comparisons at post-test showed significant differences for the word definitions and vocabulary subtests, as the control group performed better than the experimental group in both subtests. A possible reason could be that most (almost three-quarters) of the parents in the control group (71.8%) reported that English was their child's dominant language in comparison to 61.9% of the experimental group parents indicating the dominance of English language. Six out of the 16 subtests of the ELLA protocol showed significant within-group differences for both groups at post-test. Four areas that showed significant improvement at post test for both groups are complex sentences, negative sentences, prepositional phrases and irregular past tense verbs. These changes may be because of maturation as these specific language abilities' skills improve rapidly during the preschool period, leading to the expansion of vocabulary and narrative skills (Lonigan et al. 2013; Owens 2012; Torppa et al. 2006).

The progression of complex sentence production is reflected in the emergence and development of negative sentence structure from approximately 27 months onwards (Owens 2012). By age 3, most children can talk about the location of an object and by age 4, children use post-noun prepositional phrases (Owens 2012). It is widely acknowledged that 80% of the pre-schoolers correctly use certain irregular past tense verbs between the ages of 3 and 5 years and by 46 months, children have usually mastered irregular past tense verbs (Owens 2012; Roth & Worthington 2019). Children also develop narrative skills within their home environment and their language communities (Owens 2012). Exposure to narratives during shared book reading supports the development of decontextualised language and in turn helps children to make the shift from the language used at home to the decontextualised language used in the classroom (Rowe 2013; Wium & Louw 2011).

mHealth applications may provide the required bridge between the language acquisition in the home and classroom environments by supporting both caregivers and ECD practitioners. Parental engagement with the application may, however, be a barrier, as demonstrated in the current study findings (Marturana 2012). Parental participation with mHealth-based applications could be increased by

providing parents with more consistent support with mobile applications (Marturana 2012).

An existing mHealth platform that has received a positive response from South African parents is MomConnect. This awareness campaign provides mothers with weekly text messages linked to the stage of their pregnancy and has reached more than half (63%) of all pregnant women in South Africa attending antenatal appointments at public health care facilities (Barron et al. 2018). MomConnect may provide a working example for CareUP to facilitate improved parental engagement, although limitations have been identified. MomConnect lacks centralisation as text messages stop when infants become 1 year old; however, it is recommended that the platform extends to include ECD and maternal mental health information until the child is 5 year old (Barron et al. 2018). Through centralisation, CareUP may be able to overcome this gap and provide language stimulation, as this is a core developmental domain for later academic performance (Spilt et al. 2015; Zauche et al. 2016). Centralisation of available mHealth parental applications, such as MomConnect and CareUp, should be investigated as a way to provide mothers with information on pregnancy until the child reaches the age of 5 (Barron et al. 2018).

Future research should also investigate the use of an activation workshop and one-on-one parent coaching sessions during the CareUP intervention period. Additionally, the effect of the CareUp application on children's language skills when used by both the ECD practitioners and parents should be explored as they could support each other in the implementation of language facilitating activities. The current study included a small sample, therefore further large cohort experimental studies, including vulnerable children from lower socio-economic settings, are recommended to investigate the effect of an mHealth resource on language abilities.

In conclusion, the results indicate that the parents did not use the mHealth application regularly, and this may have influenced the effect of the application on their children's language abilities. Parent involvement in the acquisition of early language skills is essential, and mHealth appears to improve access to resources to support involvement and language development; however, parents may require additional support to increase their use of mHealth applications (Owens 2012; Roberts & Kaiser 2011; Shah et al. 2016). The findings of the current study suggest that future studies should consider proving parents with an activation workshop and collaborative implementation by parents and ECD practitioners.

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### Competing interests

The authors certify that they are not involved in any organisation or entity nor have any financial or personal relationships that may have inappropriately influenced them in writing this article.

### Authors' contributions

E.L.R. was involved in all aspects of the research study including but not limited to conception and design, data collection, analysis and interpretation. R.E., S.A., M.G. and J.v.d.L. were involved in all aspects of this research study, including data analysis, except the data collection.

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### Data availability

The data that support the findings of this study are available on request from the corresponding author because of privacy and ethical restrictions.

### Disclaimer

The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of any affiliated agency of the authors.

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