Developmental screening– evaluation of a mHealth version of the PEDS tools

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Running title

Developmental screening by community health workers.

Abstract

Background: Developmental delays are more prevalent in low-income countries and access to developmental screening is severely limited.

Introduction: This study evaluated an mHealth version of a standard developmental screening tool, Parents Evaluation Developmental Status (PEDS) and PEDS: Developmental Milestones (PEDS:DM) for use by community health workers (CHWs) in terms of (1) correspondence with conventional paper-based testing by a speech language pathologist (SLP) and (2) inter-rater reliability compared to an SLP.

Method: CHWs were trained in a primary health care (PHC) setting to administer the newly developed smartphone application version of the PEDS tools. One SLP and two CHWs recruited 207 caregivers who were attending a baby wellness clinic. Caregivers were tested by one CHW using the smartphone application of the PEDS tools, a qualified SLP simultaneously recorded and scored the PEDS tools on the same participants.

Results: High positive (100%) and negative correspondence (96%) was found between the paper-based PEDS tools and the smartphone application PEDS tools and between the SLP and CHW. Almost perfect (Cohen's Kappa) inter-rater agreement between conditions was demonstrated (κ=0.873 to κ=0.961).

Conclusion: Outcomes of the smartphone application, operated by a CHW, corresponded closely to the gold standard PEDS tools operated by a health professional. Trained CHWs can conduct accurate developmental screening using the smartphone version of the PEDS tools.

Introduction

Developmental screening is vital in establishing early detection and timely referral to early intervention services.[1,2] Early intervention is beneficial in that stimulation could still have an effect on brain growth and recovery.[3] During the first three years of a child's life rapid brain development occurs, which is essential for future growth, development and progress. Early intervention aims to ensure and enhance children's personal development and resilience. Children with disabilities who receive good care as well as developmental opportunities during early childhood are more likely to become healthy, productive adults. This can potentially reduce the future costs of education, medical care and social spending.[4] Ultimately, future delays can be prevented by means of early intervention.[5]

Early intervention is especially important in developing countries, such as South Africa, where the prevalence of developmental delays are high.[6] To detect developmental delays developmental screening measures can be employed.[10] Currently there is no coordinated developmental monitoring and surveillance system in place within either the public or private sector in many countries like South Africa. Developmental screening is conducted by nurses in PHC clinics that are often understaffed and underresourced.[7] A comprehensive developmental screening approach is required for appropriate care and support including early identification, assessment and early intervention planning, provision of services, and monitoring and evaluation.[4] The only implemented developmental screening tool in South Africa is integrated as part of the road to health booklet (RTHB). This tool is not standardized and has been shown to have low sensitivity (25%). There is a clear

need for an efficient developmental screening tool to improve early detection of developmental delays at community levels.[11]

The PEDS tools, a standardized and validated measure, have recently been considered for use in PHC contexts of South Africa.[11,12] Ideally a tool that is quick, reliable and which could be used by frontline health workers such as CHWs could ensure widespread access to early detection. The number of SLPs and other healthcare professionals are limited and overburdened with high caseloads in secondary and tertiary health centers.[13] The South African re-engineering of PHC policy aims to relieve burden on secondary and tertiary healthcare by strengthening referral systems to PHC.[14] Thus, the use of the PEDS tools in the South African PHC is well aligned with the PHC re-engineering policy.[14,15] In South Africa, the use of smartphone applications is part of the community oriented primary care (COPC) initiative using CHW and mHealth initiatives to deliver continuous, comprehensive, integrated and informed healthcare services to underserved communities. A developmental screening like the PEDS tools in an App format could function as part of the COPC initiative whereby CHWs conduct the smartphone application PEDS tools remotely during home visits.[16]

Identification and assessment of children with disabilities in high-income countries often involves teams of highly trained professionals.[4] The PEDS tools for example is usually administered by parents or trained developmental health professionals.[21] However, in low and middle income countries such comprehensive expertise is often inaccessible and poor parental literacy skills may pose a challenge.[4] In some countries, CHWs are trained and supported by professionals to strengthen capacity and improve the quality of interventions.[4,16,22] CHWs can extend care to underserved

communities, drawn from local communities. They speak the languages and identify with the local community to convey health messages more effectively.[22] CHWs can therefore be uniquely positioned for early detection of developmental concerns if the right tools that are simple, cost and time efficient are available.[16] The PEDS tools could potentially be used in the form of a mobile phone-based assessment for developmental screening by CHWs. CHWs using mHealth tools has been proposed as an important way to improve access to health care services for early detection and subsequent care for community members.[16,23] This study therefore aimed to evaluate developmental screening in terms of (1) correspondence between conventional testing using paper-based methods by the SLP and testing using a smartphone application by the CHW and (2) inter-rater reliability between the SLP and CHW.

Methods

Participants

Data were collected at Stanza Bopape Clinic, a government PHC facility in Mamelodi, Gauteng Province, South Africa. Due to office space shortages at the clinic, a private mobile office was set up. CHWs were trained on administering the smartphone-based version of the PEDS tools as part of an outreach program. Three CHWs were asked upon completion of the training to volunteer to participate in the study. Two female CHWs with five years CHW experience assisted with recruiting participants. One male CHW who had six years CHW experience in the PHC setting and no tertiary qualifications was administering the smartphone PEDS tools. All the

CHWs daily utilise smartphone applications in the PHC setting as part of their service delivery (i.e. health registrations and general risk surveys).[16]

A convenience and disproportionate stratified sampling method was utilized to select 207 caregivers who were waiting in a queue at a baby wellness clinic at Stanza Bopape Clinic.[25] Caregivers who were not proficient in English were excluded from the study. Caregivers attending the clinic with their child or children were asked to voluntarily participate in the study. Mothers were 88% (n=182) of respondents, 7% (n=15) other family members and 4% (n=9) were fathers. Sepedi was 44% (n=90) of the caregivers' first language, 15% (n=30) were Tsonga, 12% (n=24) were Zulu speakers and 29% (n=63) had other languages as their first language. Caregivers were divided into a stratified sample according to the age groups of their children. The age groups were 6-18 months 69% (n=142) and 19-36 months 31% (n=65). The mean was 1.937 and standard deviation was 1.3549, 99.9% (n=206) of children screened were black and 0.5% (n=1) were other.

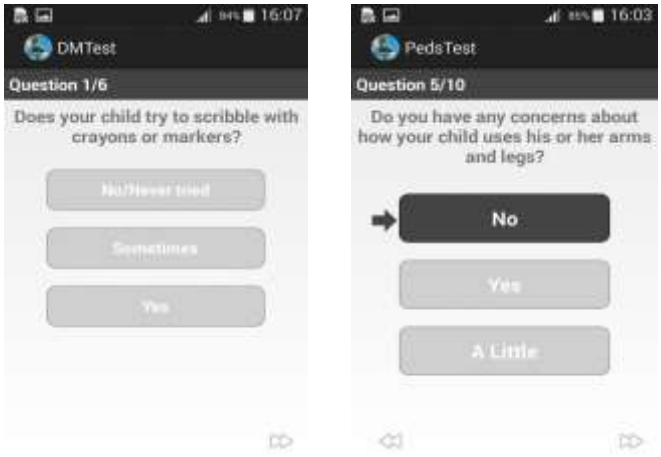
Material and Equipment

In this study, the PEDS and PEDS:DM combined, are referred to as the PEDS tools for reporting purposes. The PEDS tools are a developmental screening tool by parental report which was used to collect data. The PEDS elicits parents' concerns about children's language, motor, self-help, early academic skills, behaviour and social-emotional/mental health. The PEDS consists of ten questions, such as; Do you have any concerns about how your child understands what you say? Do you have any concerns about how your child behaves? The PEDS:DM is indicative of children's skills across all developmental domains; expressive language, receptive language, fine motor, gross motor, social-emotional, self-help and academics. The

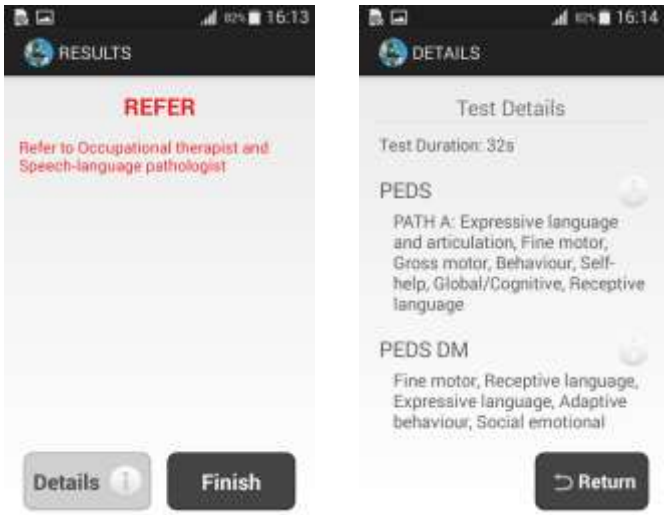
PEDS:DM consist of 6-8 questions, such as; Can your child walk without falling much? Does your baby drink (not suck) from a cup?[12]

Figure 1 Screenshot of the PEDS tools application. (a) Example question; (b) response options; (c) Results screen; (d) Results description

(a) **(b)**



(c) **(d)**



An hour training session on administering the PEDS tools on a smartphone application was provided to the CHWs in person utilizing a training module of the

PEDS tools and the PEDS tools guide to administration and scoring. The PEDS tools were developed into a smartphone application, using the same algorithm as the conventional paper-based PEDS tools. Two Samsung Neo Trend smartphones (Android OS 4.4.1), were used to install the PEDS tools application. The PEDS tools application was developed by the University of Pretoria, evaluated and piloted by two SLPs on eight caregivers. Screenshots of the PEDS tools application are presented in figure 1.

Data collection

CHWs were trained and thereafter, caregivers were interviewed by the CHW using the smartphone application of the PEDS tools, simultaneously a qualified SLP was recording and scoring the PEDS tools on the same participants. The SLP completed the PEDS tools, based on caregiver responses, using either the smartphone application or conventional paper-based version in a counter-balanced manner. The CHW only administered the smartphone version. In order to eliminate bias, the SLP and the CHW did not communicate, make contact or view each other's records during testing. The PEDS tools were administered concurrently by the SLP and CHW to ensure the context and caregiver responses, as elicited by the CHW, were similar.

Scores of the paper-based PEDS tools completed by the SLP were manually captured and uploaded to the same server as the smartphone application server. Caregivers whose children obtained referral results according to the findings of the SLP were issued with referral letters to the relevant health care professionals for follow-up.

Data Analysis

The Statistic Package Social Sciences (SPSS) v22 (Chicago, Illinois) was used for statistical calculations and analysis.[27] Frequency distributions, cross tabulations and descriptive statistics depicting the mean, standard deviation, minimum and maximum values were used to analyse data. Pivot tables were used to calculate positive correspondence which determined the proportion of positive screen outcomes correctly identified and negative correspondence which measured the proportion of negative screen outcomes that were correctly identified. Positive and negative correspondence was calculated for paper-based and smartphone application PEDS tools as well as for the results obtained by the CHW and the SLP.[28] Cohen's Kappa coefficient was used to establish the inter-rater agreement between the paper-based and smartphone application PEDS tools as well as between the SLP and CHW. Inter-rater agreement was classified according to the Landis and Koch-Kappa's Benchmark Scale into poor (κ=<0.0), slight (κ=0.0-.20), fair (κ=0.21-0.40), moderate (κ=0.41-0.60), substantial (κ=0.61-0.80), almost perfect (κ=0.81-1.00).[29,30]

Results

A total of 207 children were assessed using the PEDS tools by the CHW and the SLP. Half of the children (51%) were assessed using the paper-based PEDS tools (odd-numbered participants) and the other half (49%) were assessed using the smartphone application (even-numbered participants) by the SLP. Referral rates were similar when the outcome of the CHW and the SLP were compared. Similar referral rates were also yielded when the paper-based outcomes were compared to

the outcomes of the application (Table 1). The SLP and the CHW also found similar referral rates across age categories (Table 2).

High positive and negative correspondence was found between the paper-based PEDS tools and the smartphone application PEDS tools, as well as between the SLP and CHW (Table 3). Higher positive and negative correspondence was noted in the younger 6-18 months age group (Table 3). High Inter-rater agreement between conditions varied from κ=0.873 to κ=0.961 (Kappa score; Table 4).

Table 1: Distribution of PEDS tools outcome for CHW and SLP (*n*=207 children)

	CHW (n=207)	SLP (n=207)	SLP - Paper-based (n=105)	SLP - App (n=102)
Pass	40%	42%	41%	43%
Refer	60%	58%	59%	57%

App, application

Table 2: Age specific outcomes of the PEDS tools (n=207 children)

	6-18 months CHW (n=142)	6-18 months SLP (n=142)	19-24 months CHW (n=65)	19-24 months SLP (n=65)
Pass	49%	49%	22%	26%
Refer	51%	51%	78%	74%

Table 3: Correspondence of the PEDS tools

	Positive correspondence	**Negative correspondence**	**Overall Correspondence**
SLP vs CHW (n=207)	99%	97%	95%
Smartphone vs Paper-based (n=105)	100%	96%	100%
Smartphone vs Smartphone (n=102)	98%	98%	100%
SLP vs CHW (6-18 months) (n=142)	100%	99%	100%
SLP vs CHW (19-36 months) (n=65)	98%	88%	100%

Vs, versus

Table 4: Inter-rater agreement (Cohen's Kappa) for the CHW using the AB and the SLP using conventional PB and AB versions of the PEDS tools

	κ Value	Standard Error
CHW-AB and SLP-PB/AB (n=207)	.960	.020
CHW-AB and SLP-PB (n=105)	.961	.027
CHW-AB and SLP-AB (n=102)	.959	.029
CHW-AB vs SLP-PB/AB (Age 6-18 months) (n=142)	.986	.014
CHW-AB vs SLP-PB/AB (Age 19-36 months) (n=65)	.873	.071

AB, Application based; PB, Paper-based

Discussion

The smartphone-based version of the PEDS tools developed for this study operated by CHWs corresponded exactly with the paper-based version completed by a SLP in 99% of instances (n=207). Agreement was therefore almost perfect (κ=0.960; Cohen's Kappa) between test outcomes by a CHW using the application and results obtained by a health professional (SLP) using conventional paper-based testing. Previous studies have reported that CHWs can provide high-quality care and bridged the gap between patients and healthcare providers.[31] Furthermore, CHWs were found to fulfil a crucial role in smartphone-based hearing screening and management of non-communicable diseases.[23,32] It has also been reported in a South African study that a trained lay telehealth clinic facilitator was effective to capture reliable images of the eardrum for accurate asynchronous diagnosis by an otolaryngologist.[33] CHWs who are part of the COPC initiative are frontline health workers that are more accessible and cost effective than SLPs and other healthcare practitioners.[16] The PEDS tools smartphone application, when used by users with different levels of training, was demonstrated to be reliable. CHWs who receive appropriate training

will be able to effectively administer developmental screening using the smartphone-based PEDS tools application.

Outcome on the PEDS tools application corresponded with those found on the conventional paper-based PEDS tools (Table 3). The PEDS tools smartphone application was accurate and maintained the integrity of the conventional PEDS tools. Developmental screening by CHWs utilizing a smartphone-based version of the PEDS tools could be beneficial in underserved South African communities, where children are at an increased risk of developmental delays.[6,11] The use of a developmental screening tool like the PEDS tools operated from a smartphone could ensure availability of developmental screening services and referrals to appropriate healthcare professionals for earlier intervention. The RTHB screening done by nurses in South Africa has limitations.[11] The PEDS tools may offer an advantage and decentralise current screening initiatives from clinics to homes.

The use of smartphone applications in healthcare has been shown to improve access to PHC services.[23] The use of the PEDS tools as part of the COPC initiative would assist in early developmental delay detection for the reasons that CHWs are already doing occasional home visits using smartphones. Caregivers would receive informational counselling on early development and early intervention could take place remotely. Furthermore, test results can be sent to a cloud-based service whereby the information would be accessible and safe. In addition, caregivers would be provided with referral appointments.

A high referral rate was obtained by both the SLP and CHW in the sample population. A possible reason for this may be due to the children being from a high risk population.[6] Similar referral rates have been reported in a previous study

conducted in other South African underserved communities.[11] In contrast, a study conducted on a global scale, including data from 11 countries, depicted a lower referral rate of 34%.[34]

The high referral rate noted in the above mentioned South African contexts maybe problematic as the already overburdened health care system may not be able to provide effective and accountable services to all, should developmental screening be implemented on a large scale. The PEDS tools referral algorithm may need to be adapted for the South African underserved population to ensure that moderate to severe developmental delays are detected as well as referred and that mild developmental delays are followed up by means of developmental surveillance. This could be implemented to obtain more reasonable referral rates. A validation of the application should be done evaluating the smartphone PEDS tools against a PEDS tools as a diagnostic gold standard tool. Furthermore, it should be determined if caregivers will be able to effectively administer the PEDS tools smartphone application.

Conclusion

Almost perfect agreement between conventional testing using the paper-based PEDS tools and the PEDS tools as a smartphone application was found. Furthermore, almost perfect inter-rater agreement between the SLP and CHW was reported. CHWs who have been trained successfully conducted developmental screening using the smartphone version of the PEDS tools. COPC initiatives may be a viable platform to render smartphone-based developmental screening to high risk

communities. CHWs can conduct developmental screening in high risk communities easily with the smartphone application and results can be integrated into a telehealth framework to provide appointments, reminders, informational counselling and even early tele-intervention services. This makes early detection of developmental delays in underserved communities possible towards preventative measures and early initiation of necessary interventions.

The PEDS tools was only administered by the SLP and CHW, this was found to be a limitation in this study as the accuracy of the PEDS tools application administered by a group of participants with varying knowledge on child development was not evaluated. It is therefore recommended that the PEDS tools smart phone application should be evaluated when administered by parents themselves as well as various health professionals such as nurses, occupational therapists, paediatricians and general practitioners.

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Disclosure statement

No competing financial interests exist

References

1. Conatser P, James E, Ledingham C. Early intervention developmental screening assessment. *Palaestra* **2013;** 23: 37-41.

2. Fernell E, Wilson P, Hadjikhani N, Bourgeron T, et al. Screening, intervention and outcome in autism and other developmental disorders: the role of randomized controlled trials. *J Autism Dev Disord* **2014;** 44: 2074-2076.

3. Sonnenschein B, Conover K, Shizgal P. Growth of brain stimulation reward as a function of duration and stimulation strength. *J Behav Neurosci* **2003;** 117: 978-994.

4. World Health Organization (WHO). Early childhood development and disability: discussion paper. **2012.** Available at http://apps.who.int/iris/bitstream/10665/75355/1/9789241504065_eng.pdf (Accessed October 10, 2014).

5. Groark CJ, Eidelman SM, Maude S, et al. *Early childhood intervention: Shaping the future for children with special needs and their families.* 1st ed. California: Praeger, **2011:** 80.

6. Van der Linde J, Swanepoel DW, Glascoe FP, et al. Risks associated with communication delays in infants from underserved South African communities. *Afr J Prim Health Care Fam Med* **2015;** 7: 841-847.

7. Samuels A, Slemming W, Balton S. Early childhood intervention in South Africa in relation to the developmental systems model. *Infants Young Child* **2012;** 25: 334–345.

8. Rosenberg SA, Zhang D, Robinson CC. Prevalence of developmental delays and participation in early intervention services for young children. *Acad Pediatr* **2008;** 121: 1503-1509.

9. Ozkan M, Senel S, Arslan EB, et al. The socioeconomic and biological risk factors for developmental delay in early childhood. *Eur J Pediatr* **2012;** 171: 1815-1821.

10. Lynn D, Newton HB, Rae-Grant AD. *The 5-Minute Neurology Consult*. 2nd ed. Philadelphia: Lippincott Williams & Wilkins, **2012:** 164-165.

11. Van der Linde J, Swanepoel D, Glascoe FP, et al. Developmental screening in South Africa: comparing the national developmental checklist to a standardized tool. *Afr J Health Sci* **2015;** 15: 188-196.

12. Glascoe FP and Robertshaw NS. *PEDS' Developmental milestones a tool for surveillance and screening professionals manual*. 2nd ed. USA: Ellsworth & Vandermeer Press, LLC. **2010:** 1-177.

13. Van der Linde J, Kritzinger A. Perceptions of rural primary healthcare personnel about expansion of early communication intervention. *Afr J Prim Health Care Fam Med* **2013;** 5: 553-564.

14. Mohapi MC, Basu D. PHC re-engineering may relieve overburdened tertiary hospitals in South Africa. *S Afr Med J* **2012;** 102: 79-80.

15. Heunis C, Wouters E, Kigozi G, et al. TB/HIV-related training, knowledge and attitudes of community health workers in the Free State province, South Africa. *Afri J AIDS Res* **2013;** 12: 113-119.

16. Bam N, Marcus T, Hugo J, et al. Conceptualizing Community Oriented Primary Care (COPC) – the Tshwane, South Africa, health post model. *Afr J of Prim Health Care Fam Med* **2013;** 5: 13-15.

17. Kiing JSH, Low PS, Chan YH, et al. Interpreting parents' concerns about their children's development with "Parents Evaluation of Developmental Status (PEDS)": Culture Matters. *J Dev Behav Pediatr* **2012;** 33: 179-183.

18. Coghlan D, Kiing J, Wake M. Parents' evaluation of developmental status in the australian day-care setting: Developmental concerns of parents and carers. *J Paediatr Child Health* **2003;** 39: 49-54.

19. Radecki L, Sand-Loud N, O'Connor G, et al. Trends in the use of standardized tools for developmental screening in early childhood: 2002–2009. *Pediatrics* **2011;** 128: 14-19.

20. Marjolaine ML, David PPJ. Comparison of the ASQ and PEDS in screening for developmental delay in children presenting for primary care. *J Paediatr Child Health* **2011;** 32: 1-13.

21. Brothers KB, Glascoe FP, Robertshaw NS. PEDS: Developmental Milestones-An accurate brief tool for surveillance and screening. *Clin Pediatr* **2008;** 47: 271-279.

22. Tulenko K, Møgedal S, et al. Community health workers for universal health-care coverage: from fragmentation to synergy. *Bull World health organ* **2013;** 91.

23. Hussein SY, Swanepoel DW, de Jager LB, Myburgh C, Eikelboom H, Hugo J. Smartphone hearing screening in mHealth assisted community-based primary care. *J Telemed Telecare* **2015;** 0: 1-8.

24. Statistics South Africa. Census. **2011.** Available at www.statssa.gov.za/Census2011/default.asp (Accessed September 02, 2014).

25. Bernard HR. *Social research methods: Qualitative and quantitative approaches*. 2nd ed. USA: SAGE Publications, **2012:** 133.

26. WMA Declaration of Helsinki - Ethical principles for medical research involving human subjects. **2013.** Available at http://www.wma.net/en/30publications/10policies/b3/ (Accessed August 21, 2015).

27. Willium E, Wagner III. *Using IBM® SPSS® statistics for research methods and social science statistics.* 5th ed. California: SAGE Publications, **2014:** 1-5.

28. Healey J. *The essentials of statistics: A tool for social research*. 4th ed. Boston: Cengage Learning, **2015:** 25.

29. Gwet L. *Handbook of Inter-Rater Reliability, 4th Edition: The Definitive Guide to Measuring The Extent of Agreement Among Raters*. 4th ed. Gaithersburg: Advanced Analytics, **2014**.

30. Shrout PE, Spitzer RL, Fleiss JL. Quantification of agreement in agreement in psychiatric diagnosis revisited. *Arch Gen Psychiatry* **1987;** 44: 172-177.

31. Collinsworth AW, Vulimiri M, Schmidt KL et al. Effectiveness of a community health worker-led diabetes self-management education program and implications for CHW involvement in care coordination strategies. *Diabetes Educ* **2013;** 39: 792-799.

32. Tsolekile LP, Puoane T, Schneider H, et al. The roles of community health workers in management of non-communicable diseases in an urban township. *Afr J Prm Health Care Fam Med* **2014;** 6: 693-701.

33. Biagio L, Swanepoel DW, Adeyemo A, et al. Asynchronous video-otoscopy with a telehealth facilitator. *Telemed J E Health.* **2013;** 19: 1-7.

34. Woolfenden S, Eapen V, Williams K, et al. A systematic review of the prevalence of parental concerns measured by the Parents' Evaluation of Developmental Status (PEDS) indicating developmental risk. *BMC Pediatr* **2014;** 14: 231-244.