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The development and application of a mobile-based data collection system for a growth monitoring programme in selected primary care centres in the Republic of Mauritius

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ABSTRACT

There is increased interest in child nutrition globally which has resulted in high-level commitments to address child malnutrition. However, monitoring these commitments are hindered by non-existent or weak paper-based child nutrition surveillance systems. We describe the development and application of a mobile-based data collection system in near real-time for children aged 0–5 years attending government growth monitoring sessions in selected primary care centres in the Republic of Mauritius. The mobile-based data collection form was designed using KoBoToolbox and was used in the growth monitoring programme across two districts in the north of the country. We observed nine primary care centres over a period of 18 days and collected routine data on weight from 576 children. A short questionnaire and interviews were conducted with a member of healthcare staff involved in the growth monitoring programme to measure the usability and explore the perceptions of an electronic data collection form. Prevalence estimates of child underweight and overweight were also calculated. Eight out of 10 (80%) participants obtained a System Usability Scale score >80. Healthcare staff believed that the mobile-based form had the potential to reduce their workload and reduce data transmission time. An important deployment-related issue was the need for adequate training in the use of a mobile device to collect nutrition surveillance data. Overall, 5.5% (95% CI 3.9% to 7.7%) of children were underweight and 4.4% (95% CI 3.0% to 6.5%) were overweight. Through the development and implementation of this mobile-based data collection system, we have shown the value and potential usability for mobile technologies to strengthen the child nutrition surveillance system in the Republic of Mauritius.

Summary box

- Non-existent or weak child nutrition surveillance systems hinder a country's ability to characterise the burden of malnutrition, prioritise public health and clinical actions, and evaluate programmes.
- A mobile-based data collection system for a growth monitoring programme in selected primary care centres in the Republic of Mauritius was demonstrated to be usable to healthcare staff.
- Potential benefits of using a mobile-based data collection form for growth monitoring sessions rather than a paper-based form include reduced staff workload and faster data transmission.

INTRODUCTION

National nutrition surveillance systems are essential for contributing information to assess and characterise the burden of malnutrition, prioritise public health and clinical actions, and monitoring the impact of prevention and control measures as well as progress towards the Global Nutrition Targets for 2025.[1] However, non-existent or weak paper-based child nutrition surveillance systems are typically found in low- andmiddle-income countries.[2]The collection and management of child nutrition surveillance data using paper-based methods has several limitations including high probabilities for errors, delays in data transmission and a reduced ability to monitor and respond to nutrition disorders at a regional or population level.[2 3]

Currently, 30%of children under 5 years living in Africa are stunted, 7.1% are wasted and 4.9% are overweight.[4] As a WHO member state, the Republic of Mauritius, a sub-Saharan African country 2000 km off the east coast of mainland Africa, has endorsed the 2025 Global Nutrition Targets and is committed to monitoring progress. While the Republic of Mauritius has a child (0–5 years) nutrition surveillance system, country estimates are absent from WHO country statistics and Global Nutrition Reports.

In sub-Saharan Africa, there is increasing interest in the use of mobile and wireless

technology (mHealth) for child nutrition surveillance.[2 5 6] However, a number of challenges in using mobile and wireless technologies for surveillance have been reported. These includedlimited or fluctuating network coverage, insufficient technical skills of health workersas well as overstretched health workers.[2]

We describe our approach to strengthen the child nutrition surveillance system in the Republic of Mauritius by developing a mobile-based data collection system for the growth monitoring programme, the challenges encountered and how we intend to overcome the challenges.

THE COUNTRY CONTEXT

The country has a paper-based child nutrition surveillance system which collects raw values of weight data among children aged 0–5 years from the growth monitoring programme in all government primary care centres typically once or twice a month. Two healthcare teams cover growth monitoring sessions within a district. Based on the WHO growth chart percentiles, nurses classify children as underweight, normal weight or overweight. The number of cases of underweight and overweight are sent to regional nutritionists who aggregate the count data by region and then statistical officers at the Ministry of HealthandQuality of Life (MOH) aggregate the count data nationally.Transfer of data takes months to reach a level at which it can be aggregated. National and district-level underweight and overweight prevalence estimates are subsequently published annually in the MOHHealth Statistics Report and have indicated extremely low prevalence estimates for over a decade (table 1).

APPROACH

An electronic data collection form for use on a mobile device was developed and implemented in growth monitoring sessions in two districts (Riviere du Rempart and Pamplemousses) located in the north of the country between 2017 and 2018. Mauritius is divided into nine districts. These two districts were purposefully selected on the basis that healthcare teams were familiar with previous initiatives to improve child nutrition surveillance in primary schools. Design thinking, an analytic and creative process that engages end-users in opportunities to experiment, create and prototype a product or service, gather feedback, and redesign,[7 8] was employed throughout the project. The implementation of the mobile-based data collection form was accompanied by observations, a short questionnaire to measure the usability of the form, interviews to further explore the perceptions among healthcare staff and calculation of underweight and overweight prevalence estimates.

The study was approved by the MOH and healthcare staff gave verbal consent to participate in the study.

DEVELOPMENT OF A MOBILE-BASED DATA COLLECTION FORM

Following the stages of design thinking, we first observed and talked to staff directly involved in child nutritional surveillance (eg,chief nutritionist, chief statistician, regional nutritionists, public health nurses, and statistical officers). We were interested to understand the current nutritional surveillance system workflow (figure 1), what their actions were, how they think, what they want and what kind of constraints existed. We then brainstormed ideas based on what we learnt and hypothesised that the paper-based data collection procedures and associated

Table 1 Prevalence of underweight and overweight among children aged 0–5 years attending growth monitoring session in Mauritius

	National		Pamplemousses		Riviere du Rempart	
Year	Underweight (%)	Overweight (%)	Underweight (%)	Overweight (%)	Underweight (%)	Overweight (%)
2007	0.9	0.9	–	–	–	–
2008	0.7	0.6	–	–	–	–
2009	0.4	0.2	–	–	–	–
2010	0.1	0.1	–	–	–	–
2011	0.1	0.1	0.0	0.0	0.0	0.0
2012	0.2	0.1	0.0	0.0	0.0	0.0
2013	0.3	0.1	0.0	0.0	0.0	0.0
2014	0.3	0.3	0.0	0.1	0.0	0.0
2015	0.4	0.4	0.0	0.1	0.0	0.0
2016	0.3	0.2	0.1	0.0	0.0	0.0
2017	–	–	–	–	–	–
2018	–	–	–	–	–	–

Source: Ministry of Health and Quality of Life Health Statistics Report.

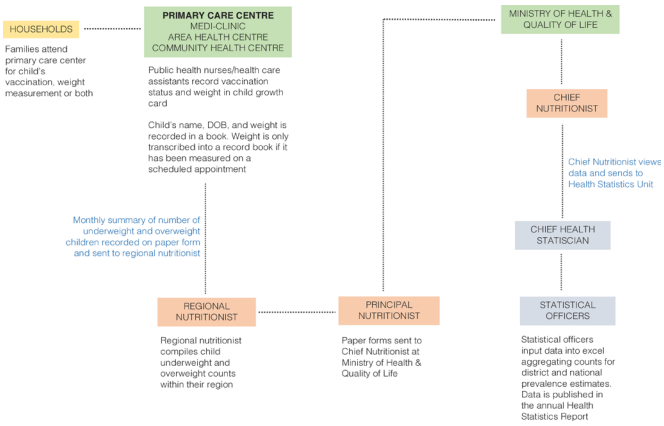

Figure1 Workflow of the child (0-5 years) nutrition surveillance system in the Republic of Mauritius.

practical challenges (eg, improving data quality and time taken for data transmission) might be addressed using mobile and wireless technology.

The design of the mobile-based data collection form was based on the routine child nutrition data collected at the growth monitoring clinic. We field tested several iterations of the form using KoBoToolbox (http://www.kobotoolbox.org/) and Enketo (also known as Webforms). KoBoCollect is a data collection Android app based on Open Data Kit that can be installed on any standard Android phone or tablet. Enketo is embedded with KoBoToolbox and allows building and previewing forms entirely offline as well as allowing data collection online or offline. The form had the ability to capture data which can be securely transmitted to the central server (hosted by Amazon Web Services) via Wi-Fi. Other alternative methods include mobile phone network or direct cable.

The mobile-based data collection form was deployed in nine primary care centres located in the two districts to collect routine data from the growth monitoring programme between 28 January 2018 and15 February 2018. Data on age, sex, weight and clinic location were collected on tablets from 576 children and synced to the KoBoToolbox database when Wi-Fi was available. These data were then extracted as a CSV file and then imported into Stata Statistical Software: Release V.14.0 for statistical analysis on a computer. Continuous variables with a normal distribution were presented as means (SD), non-normal variables were reported as medians (IQR) and proportions and 95%CIs for categorical variables. Weight-for-age Z scores were calculated using the 'zanthro' anthropometric modules in Stata, which uses the WHO 2006 growth standards. Weight-for-age Z scores were calculated in SD units. Children with a Z score of <−2SD were classified as underweight and children with a Z score of >2 SD were classified as overweight.[9]

PRETEST OF A PROTOTYPE OF THE ELECTRONIC DATA FORM

We conducted live prototyping of the mobile-based data collection form for 19 days on 10 healthcare staff working across 9 primary care centres in the 2 districts. The usability of the electronic data collection form was measured and interviews to explore perceptions of healthcare staff were conducted. Participating healthcare staff from growth monitoring clinics who volunteered to use the electronic data collection form were selected. Participants were all female and included healthcare assistants (n=5), public health nursing officers (n=3) and student nursing officers (n=2).

THE USABILITY OF THE MOBILE-BASED DATA COLLECTION FORM

Usability, defined as 'the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use' was measured using the System Usability Scale (SUS).[10 11] The SUS is a short validated and widely used questionnaire for usability testing, formed of 10 items with a Likert Scale (5 response options from strongly agree to strongly disagree).[11]

We distributed the questionnaire among the healthcare staff that had been using the prototype of the mobile-based data collection form and the SUS score was calculated using the formula: final SUS score = [(odd numbered items − 1) + (5 − even numbered items)] × 2.5. A final SUS score of 68 is considered as average and a score above 68 indicates satisfaction.[11] The higher the SUS score, the more likely the healthcare staff would recommend the use of tablet.

We additionally observed whether healthcare staff were able to use the data collection form to record child's characteristics and weight data with ease, difficulty or failed to use the mobile-based data collection form and measured the time taken to complete inputting data for one child.

Eight out of 10 healthcare staff obtained a SUS score higher than 80, which means that they were very satisfied with using the tablet. Eight healthcare staff were able to complete the mobile-based data collection form with ease, whereas two of them required guidance to complete the form. The mean time to complete data entry for a child was 69 s.

PERCEPTIONS OF HEALTHCARE STAFF ON THE MOBILE-BASED DATA ENTRY FORM

A total of 10 face-to-face semi-structured interviews were conducted in Creole or English with healthcare staff. Guided by a topic guide, they were asked about their perceptions on the mobile-based data collection form, how confident they felt using the tablet, the challenges encountered, advantages and disadvantages, as well as their preference between using the mobile-based form or the paper-based forms. Interviews were audio recorded, transcribed and translated into English (where necessary) for analysis. Transcripts were uploaded onto NVivo software V.11, and thematic analysis, as defined by Clarke and Braun, was undertaken to identify key themes.[12]

Two main themes emerged from the interviews: acceptability and practicality. Each of these themes were further categorised into subthemes.

Acceptability

The theme acceptability referred to healthcare staff's views on whether the tablet was pleasing and suitable for their work, and was further categorised into four subthemes: tablet ownership and level of confidence, workload reduction, satisfaction and suitability for work.

Healthcare staff who owned a personal tablet at home reported that they were most confident in using a tablet to record child anthropometric data. Those staff less familiar with tablets, mentioned they were least confident in using a tablet in a reasonable amount of time and found inputting data difficult. However, after further use of the tablet, the least confident healthcare staff felt more confident in using the tablet. Over half of the staff remarked that use of the tablet would remove the need to compile monthly records in their record books which would ultimately decrease their workload.

> If there will be no need to compile data or to do statistics at the end of the month, then I will prefer the tablet (healthcare staff 7).

> It is very practical and can be easily brought to any session (healthcare staff 2).

Moreover, the majority of the healthcare staff said they would recommend the use of the tablet because it appears '*professional and modern*' and '*easy to use and rapid*'.

Practicality

Practicality referred to factors that affected tablet usage and encompassed considerations of data entry time, caregiver perceptions, technical issues, tablet ownership, training, responsibility and data security.

Most of the healthcare staff reported spending less time on completing the data collection form on the tablet compared with a paper record.

> …we need to write on many books which take us more time compared to just inputting data into the tablet (healthcare staff 8).

> …the form already has the options female, male, weight so I will not need to write these. But on paper I need to write all of this (healthcare staff 1)

Healthcare staff suggested that busy clinic sessions may affect tablet use and this was linked to their view on caregiver's perceptions.

> When we have hectic sessions, there is a long queue and using the tablet would be too time consuming. Sometimes parents do not understand and all this can cause delay and create problems in the sessions (healthcare staff 3).

One member of staff suggested that they have to explain the process to caregivers but also, it was mentioned that with time and practice this situation will change and parents will not have to wait. Healthcare staff highlighted several technical issues that might affect the routine use of the tablet. One staff member was concerned about situations when the tablet had low battery power and another participant was concerned about the app crashing.

A couple of healthcare staff who reportedthat they had vision problems also reported difficulties using the tablet because of its screen size. They suggested using a tablet with a larger screen or increasing the size of characters.

Adequate training and practice on using tablets was emphasised by most healthcare staff.

> There is a saying practice makes perfect, so I feel if we practice more often, we can become experts at using the tablet (healthcare staff 3)

The majority of healthcare staff remarked that someone needed to take responsibility of the tablet but expressed reluctance to take responsibility themselves, whereas another member of staff raised concerns if they lost the tablet. The majority of the staff reported that record books had been lost and time was spent looking for them. They commented that data would be more secure and accessible on tablet.

> I would not take it, because it is government property and we have no right to bring any government property at home (healthcare staff 2)

> I feel that the information will always be present in the database. Anytime information will be needed, it can be easily retrieved (healthcare staff 6)

NUTRITION STATUS OF CHILDREN UNDER 5

We excluded 10 children because of duplicate records and one child who had a weight-for-age Z value≥5, resulting in a sample of 565 children (286 boys and 279 girls) with a median age of 15.0 months (IQR 6.0–27.0). The median weight-for-age was −0.17 SD (IQR −0.86 to 0.69). Overall, 31 (5.5%, 95% CI3.9% to 7.7%) children were underweight and 25 (4.4%, 95% CI3.0% to 6.5%) were overweight. We also calculated stratified prevalence estimates for childh underweight and overweight by sex, age groups (under 6 months and 6 months and over), district and clinic (figures 2 and 3).

BENEFITS TO USING A MOBILE-BASED DATA ENTRY SYSTEM FOR GROWTH MONITORING SESSIONS

There are several benefits to using a mobile-based data collection form. First, the use of the mobile-based data collection form encouraged healthcare staff to record weight in every child attending the growth monitoring session and enabled transmission of data for analysis. This is important, because we learnt that healthcare staff made ad hoc decisions on which child was measured and recorded as well as the child's nutrition status. Second, the addition of key data elements (including child's date of birth, sex and clinic location) to the mobile-based data collection form allowed for quick disaggregation of the data by age, sex and geographic area during analysis, which can provide useful information on which groups

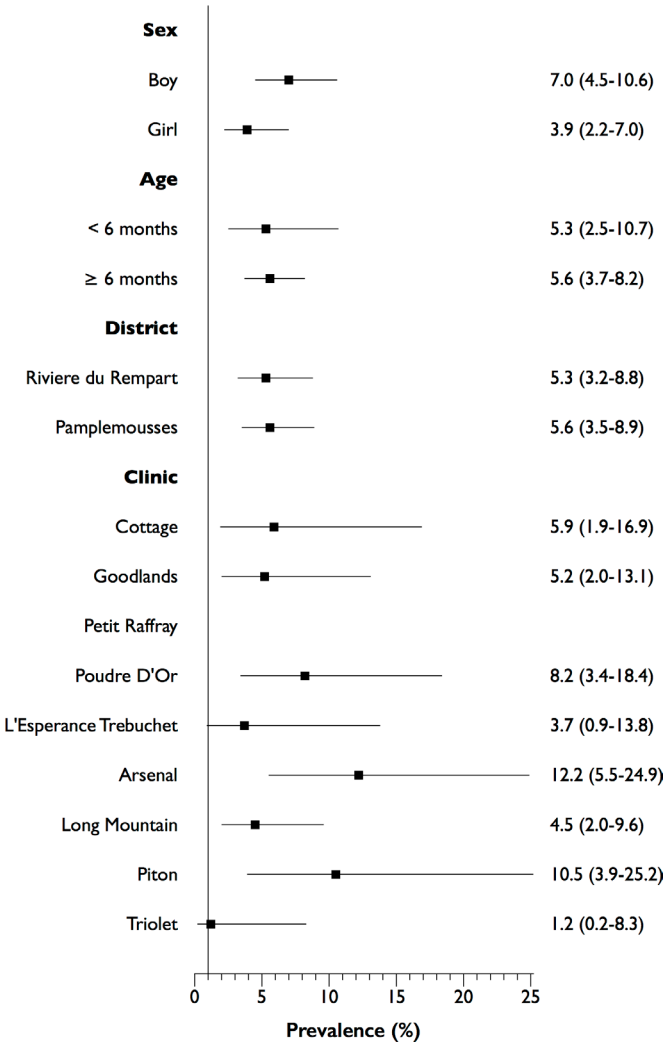

Figure 2 Prevalence of underweight among children aged 0–5 years from mobile-based nutritional surveillance.

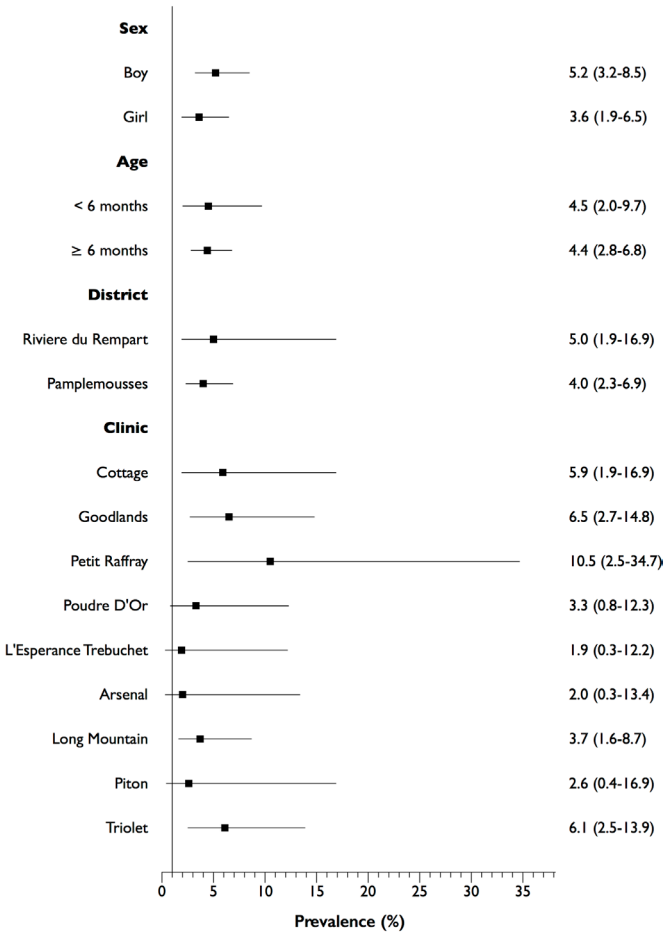

Figure 3 Prevalence of overweight among children aged 0–5 years from mobile-based nutritional surveillance.

are most vulnerable. Third, we showed that we could produce estimates of child underweight and overweight prevalence on the same day based on measurements made on the same day. The existing child nutrition surveillance system takes ~12 months from collection to publication in the MOH Health Statistics Report.

Our district-level prevalence estimates of underweight and overweight were considerably higher than the district-level prevalence estimates published in the MOH annual Health Statistics Report. Further research is required to explain this wide discrepancy. While our data were collected over a much shorter period, the discrepancy maybe highlighting several sources of biases that came to our attention. For example, we observed children were being purposely selected or not selected for nutrition surveillance after weight measurement had occurred and we noted that recording and transmission of weight data did not take into account that children can attend the primary care centre multiple times in a year. Repeated weight measurements from the same child over a year without accounting for repeat observations will lead to erroneous prevalence estimates. Our mobile-based data collection form included an anonymous identifier for each child, therefore minimising this error.

KEY CHALLENGES WITH DEPLOYING A MOBILE-BASED DATA COLLECTION SYSTEM

The MOH will need to overcome diverse challenges if they are to successfully scale up the mobile-based data collection system for the growth monitoring programme. Common challenges to all mHealth interventions (including our use of a mobile-based data collection form and tablets), are that some users will not be familiar with the technology and may also have particular concerns that need addressing (eg, battery power and app crashes). Notwithstanding these challenges, it is crucial that any efforts to digitalise the growth monitoring programme occur alongside efforts to enhance data quality and analysis. The clinics we visited did not have medically approved scales. There were no length boards or stadiometers to measure child's length or height. Currently, the child nutrition surveillance system does not record stunting (low length/height-for-age < –2 SD) or wasting (weight for length/height < –2 SD). Both of which are key indictors in the WHO Global Nutrition Targets 2025. Staff involved in child nutrition surveillance have limited training in the conduct of child nutrition surveillance,

anthropometric measurement and interpretation of anthropometric data at a population level. Changing established practices, attitudes and behaviours is also challenging because each staff involved in child nutrition surveillance has competing priorities. Nurses, healthcare assistants and nutritionists have to balance other clinic duties with nutrition surveillance activities.

NEXT STEPS

Enhancing data quality and analysis is critical to strengthening the current child nutrition surveillance system and must accompany digitising the paper-based processes of the growth monitoring programme. Our ongoing discussions with the MOH, involves highlighting the lack of equipment in clinics, lack of standardised measurement procedures and the further development of the mobile-based data collection form to include automatic quality checks (to highlight outliers or prevent missing data) and infant and young child feeding indicators. Child nutrition surveillance data also needs to be more accessible, appealing and useful for decision makers at the MOH. We plan to work with the MOH and support training their statistical officers on the analysis, visualisation and reporting of child nutrition surveillance data.

CONCLUSIONS

We showed that a mobile-based data collection system developed to improve the growth monitoring programme in the Republic of Mauritius proved to be usable, highly accepted by the healthcare staff and provided high-quality data. While there is limited evidence globally on the impact of using mobile and wireless technology for nutrition surveillance,[2] existing evidence from studies that have used mobile phones for nutrition surveillance suggest that nutrition surveillance is timelier and data quality is improved.

Following this project, the WHO Inter-Country Support Team has become involved in efforts to strengthen the child nutrition surveillance system and the MOH has stopped publishing child underweight and overweight prevalence estimates in their Health Statistics Report. We now assume thatthere is an increasing awareness and focus, that will provide the right circumstances and enabling conditions to contribute to the development of a robust child nutrition surveillance system in the Republic of Mauritius.

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Contributors RC conceptualised and designed the study. RM collected the data. RC, AI and RM conducted the data analysis and interpreted the results. RC and AI and RC wrote the first draft. RC and AI did the critical revisions.

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