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Mixed-Method Impact Evaluation of a Mobile Phone Application for Nutrition Monitoring in Indonesia

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July 2016

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MIXED-METHOD IMPACT EVALUATION OF A MOBILE PHONE APPLICATION FOR NUTRITION MONITORING IN INDONESIA

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Introduction

Child malnutrition (includes both under- and overweight) remains a challenge. Routine growth monitoring is a common practice that aims to: detect children at risk of malnutrition; direct essential resources when children have growth faltering; track nutrition trends; determine eligibility for counselling and other specific services; and help to make child malnutrition more visible to the child's caregivers, the community and government.

The quality and usefulness of growth monitoring is often limited by poor data quality, long delays between data collection and dissemination that prevent timely response, and shortcomings in the interpretation and use of the data. The full potential of growth monitoring is often underused both to increase knowledge and improve practices at community level and to inform decision-making for better nutrition.

The use of mobile phone technology may offer innovative opportunities to strengthen community-based growth monitoring and make it more effective for tackling child malnutrition. Despite global enthusiasm for using mobile phones for nutrition monitoring and surveillance systems, there are only very few studies that have critically assessed their application. Together with World Vision Indonesia and World Vision Canada, the Institute of Development Studies (IDS) aimed to fill this evidence gap and evaluate the piloting of a mobile phone application for community-based growth monitoring.

Scope and purpose of this evaluation

For this evaluation, a mobile phone application was integrated into the existing national growth monitoring system delivered through the integrated health posts (posyandu) programme over a period of 12 months (January 2015 to January 2016) in rural (Sikka) as well as urban (North and East Jakarta) sites in Indonesia.

The objectives were:

1. To assess the impact of the mobile phone application on **data accuracy** and hence accuracy of growth monitoring status classification of children compared to the traditional paper-based system.
2. To assess the impact of the mobile phone application on **timeliness** and hence timeliness of data submission from community to sub-district level compared to the traditional paper-based system.
3. To assess the impact of the mobile phone application on **real-time responsiveness** and hence the practice of giving feedback to caregivers compared to the traditional paper-based system.

Evaluation approach and methods

The overall approach of this evaluation was theory-based. Two context-specific factors influenced the choice of the evaluation approach:

1. The 14 study posyandus (10 in Sikka; 2 in East Jakarta; 2 in North Jakarta) for this evaluation had already been selected by the World Vision team prior to the evaluation and could not be changed.
2. It was impossible to replace the paper-based growth monitoring in the posyandus with mobile phone-based growth monitoring due to the statutory reporting obligations

of the posyandus to local- and district-level health offices and other stakeholders. Consequently, the mobile phone application needed to be introduced in parallel to the existing paper-based growth monitoring in the posyandus.

As a result, it was impossible to use common causal inference models for impact evaluation, including randomised controlled trials (RCTs), quasi-experiments and natural experiments. However, the unique setting offered the opportunity to use a counterfactual design based on the same causal inference logic: Mill's Method of Difference. In this evaluation, Mill's Method of Difference was used in a multi-site case study and combined with a realist evaluation and qualitative in-depth analysis to examine the impact of the mobile phone application on growth monitoring.

Quantitative and qualitative data collection took place continuously using a combination of routine data, surveys, topic guides and observation protocols. Quantitative analysis drew on evidence from 747 matched mobile phone and paper-based child records, time records of 52 posyandu sessions and 2,276 direct observations of growth monitoring activities at child level. Qualitative analysis drew on evidence from 42 focus group discussions with 3–6 participants each.

Findings

The mobile application increased the accuracy of growth monitoring

The mobile phone application significantly improved the accuracy of the classification of children's growth status. Without it, around one in three children were misclassified (misclassification rates ranged from 16 per cent to 63 per cent). It was mainly children that were mildly underweight who were incorrectly categorised as normal weight and thus missed for early detection of undernutrition. The mobile phone application improved the accuracy of nutritional status classification by 80 per cent on average (95% CI (75.9–83.1), p=0.005). Improvements in accuracy were greatest in the rural posyandus in Sikka (94 per cent), followed by North Jakarta (64 per cent) and East Jakarta (31 per cent). The effect of the mobile phone application was most pronounced in posyandus with younger and/or less-educated cadres (community volunteers) and in contexts within which cadres received limited training and supervision for manual growth monitoring status classification.

The mobile phone application improved the timeliness of growth monitoring

The mobile phone application improved the timeliness of data submission from the posyandu to the sub-district level significantly. Median time lag differences between the paper- and mobile phone-based systems ranged from 1.5 hours to more than ten days. The improvement in timeliness was especially pronounced in urban posyandus in Jakarta (where data submission was approximately six days faster compared with the paper-based system). Delayed data entry and slow data connections caused small delays in mobile phone-based growth monitoring. According to the qualitative data, the mobile phone accelerated the procedure of nutrition data collection by facilitating quicker retrieval of each child's details and automated classification of growth monitoring status. Nevertheless, the overall length of each posyandu session increased with the introduction of the mobile phone, mainly because cadres were more likely to provide feedback and counselling to the mothers. Mothers also actively requested to receive feedback based on the phone and were willing to wait for it.

The mobile phone application increased responsiveness during growth monitoring

Cadres who used the mobile phone for growth monitoring were significantly more likely to provide feedback and arrange follow-up counselling sessions/referrals than cadres without a phone (92.8 per cent of all feedback given was provided by a cadre with a phone; 95.8 per cent of all referrals or appointments for counselling were set up by a cadre with a phone). The realist component provided insight into how and why the mobile phone increased the responsiveness of cadres in specific contexts. In particular, in contexts where cadres were unsure of how to calculate or interpret the growth charts correctly (e.g. due to limited training/supervision, a low level of formal education, or inexperience), the automated calculation and visual presentation of the child's growth monitoring status on the mobile phone enabled cadres to provide the feedback more easily. The evidence also suggested that the mobile phone is less likely to increase responsiveness in contexts in which growth monitoring sessions are attended by high numbers of children and cadres feel overwhelmed by the resulting workload.

The evaluation also identified some unintended positive changes (e.g. higher regard for the posyandu and the cadres) and negative changes (e.g. tensions and changed power dynamics within the posyandu, and tensions with local health workers). These changes and other lessons learned (e.g. the need for ongoing technical support) may influence sustainability of the mobile phone application for growth monitoring.

Conclusions

In this impact evaluation, the mobile phone application significantly improved accuracy and timeliness of growth monitoring, as well as responsiveness to growth monitoring delivered through posyandus in Indonesia. However, the results must be treated with caution because the evaluation sites were purposefully selected and findings may not hold true for other (less well-supported) sites. Nevertheless, the rigorous evaluation approach, multiple data sources and ongoing data collection, the long evaluation period (12 months) and the integration of the mobile phone application into the existing national growth monitoring system through the posyandus provide robust scientific insights and lessons for those working on mobile phone technology for nutrition monitoring systems.

1 Introduction

Malnutrition[1] is a primary cause of child mortality and morbidity in many low- and middle-income countries. It is estimated that worldwide, 161 million children under the age of five are too short for their age (stunted), 51 million weigh less than they should for their height (wasted), and 42 million are overweight (Haddad *et al.* 2015). Malnutrition in early childhood can have life-long, irreversible consequences for a child's physical health and mental and cognitive development (Black *et al.* 2013).

Community-based growth monitoring, also referred to as nutrition assessment or nutrition monitoring (Mangasaryan, Arabi and Schultink 2011)[2] can be an important measure to improve child nutrition (especially when combined with tailored nutrition promotion) (Black *et al.* 2013; Ashworth, Shrimpton and Jamil 2008; de Onis, Wijnhoven and Onyango 2004). Ongoing nutrition assessment can facilitate early detection of children at risk for undernutrition (and overweight); it can direct essential actions and resources to children in need in a timely manner, track nutrition trends at community level, determine eligibility for counselling and other specific nutrition services, and provide an effective platform for the delivery of interventions (e.g. vitamin A supplementation, immunisations) (Mangasaryan *et al.* 2011). Community-based nutrition monitoring can help to make child malnutrition more visible to his/her caregivers, the community and government (*ibid.*; Pearson and UNICEF 1995). The availability of timely and credible community-based data on child nutrition is also important to inform citizen-led action for demanding accountability of governments and other stakeholders for the quality of nutrition service delivery (Gillespie *et al.* 2013; Joshi 2013).

The quality and usefulness of community-based nutrition monitoring is often limited by poor data (in terms of inaccurate measurement and incorrect classification of growth monitoring status based on the measurements), poor coverage, long delays between data collection, analysis and dissemination that prevent timely response, and shortcomings in the interpretation of the data (Ashworth *et al.* 2008; Barnett and Gallegos 2013; Morley 1994). Consequently, the full potential of the data is often underused both to increase knowledge and improve practices at community level and to inform decision-making and raise awareness and visibility of undernutrition at district and national government levels. Novel approaches are needed to address these challenges and make community-based growth monitoring more effective and valuable for caregivers, communities, governments and other stakeholders.

The rapid expansion of mobile network coverage, growing mobile phone penetration and decreasing service costs in most low-income countries have triggered a burgeoning interest in the use of mobile phone technology in nutrition monitoring (Barnett and Gallegos 2013; Diwan, Agnihotri and Hulth 2015). Mobile phones may help to improve the quality of nutrition data (e.g. by improving the accuracy of the growth monitoring status plotting[3]), facilitate analysis and interpretation of data, and accelerate data transfer and dissemination (Barnett and Gallegos 2013). While there is increasing enthusiasm about the integration of mobile phone technology into growth monitoring and surveillance, evidence on the effectiveness of mobile phone-based systems in resource-poor settings is scarce (Barnett and Gallegos 2013; Déglise, Suggs and Odermatt 2012; Rajput *et al.* 2012; Tomlinson *et al.* 2013). The studies that are available are based on small-scale and short-term pilots, none of which were

[1] The term 'malnutrition' describes both undernutrition and overweight.
[2] 'Growth monitoring' describes the practice of routinely weighing a child (and sometimes measuring the height) and comparing the results with a standard to monitor the child's physical development over time.
[3] Growth monitoring status plotting describes the practice of plotting anthropometric measurements of the individual child on appropriate age- and sex-specific growth monitoring charts to assess the child's physical growth and identify children at a nutritional risk.

integrated into existing national systems for nutrition monitoring. Integration of mobile phone technology into existing national nutrition programmes and systems (rather than the creation of a parallel system) has been shown to be a key factor for sustainability and potential scale-up (*ibid.*).

Child malnutrition remains a significant challenge in Indonesia, with 36 per cent of children below the age of five being stunted, 14 per cent wasted and 12 per cent overweight (Haddad *et al.* 2015). Growth monitoring (also referred to as nutrition monitoring) is one of the measures to improve child nutrition (especially when combined with tailored nutrition promotion). It facilitates early detection of children at risk of undernutrition (and overweight), it can direct essential actions and resources in a timely manner, track nutrition trends, determine eligibility for counselling and other specific nutrition services, and provide an effective platform for the delivery of interventions such as immunisations. Community-based nutrition monitoring can help to make child malnutrition more visible to the child's caregivers, the community and government.

The use of mobile phone technology may offer innovative opportunities to tackle child malnutrition more effectively. Despite global enthusiasm for using mobile phones for nutrition service delivery, there are only very few studies that have critically assessed their application. World Vision, together with the Institute of Development Studies (IDS), evaluated the piloting of a mobile phone application for nutrition service delivery in Indonesia. The mobile phone application was thereby integrated into the existing national nutrition service delivery programme through integrated health posts called posyandus over a period of 12 months (January 2015 to January 2016) in urban and rural sites in Indonesia.

1.1 Purpose, objectives and scope of this evaluation

The purpose of this impact evaluation was to assess the performance of a mobile phone application for community-based growth monitoring in Indonesia. The application aimed to strengthen the existing system and provide support and guidance to the community volunteers (cadres) responsible for growth monitoring in the posyandus. The evaluation had three main objectives:

1. To assess the impact of the mobile phone application on **data accuracy** of growth monitoring.
2. To assess the impact of the mobile phone application on **timeliness** of growth monitoring.
3. To explore the impact of the mobile phone application on **real-time responsiveness** to the growth monitoring data.

The evaluation was conducted in partnership with World Vision Indonesia and World Vision Canada (hereafter referred to as World Vision).

1.2 Structure of the report

The report is structured as follows. Section 1 provides an introduction to the evaluation, its purpose, objectives and scope. Section 2 presents the mobile phone intervention and its integration into the national growth monitoring delivered through the posyandu system in Indonesia. This is followed by a detailed description of the evaluation approach and methods used, in Section 3. Section 4 presents the findings on the impact of the mobile phone application on accuracy and timeliness of and responsiveness to growth monitoring. Finally, Section 5 presents the conclusions.

2 The mobile phone intervention in the Indonesian context

2.1 The intervention: mobile phone application for nutrition monitoring

World Vision, together with technical support from the MOTECH Suite, has designed a mobile phone-based application to facilitate growth monitoring (and other nutrition service delivery). The MOTECH Suite uses smartphones with an Android platform.

For growth monitoring, the application can be used to register the child, collect anthropometric measurements, and calculate z-scores (weight-for-age, weight-for-height, height-for-age) and to classify a child's growth monitoring status (mild, moderate or severe underweight, overweight) and growth velocities.[4] The application generates summary reports from the data, aggregates single records according to different criteria (e.g. percentage of underweight children, growth trends and average weight for single children, etc.) and also provides immediate visual feedback on the growth monitoring status (green, yellow, violet, red ribbon) and growth velocity (thumb-up and thumb-down) of the individual child (see Figures 2.1 and 2.2).

Figure 2.1 Visual feedback on child's growth velocity (compared to the previous session the child attended) on the mobile phone screen (thumb-down, thumb-up)

Source: World Vision Indonesia.

[4] 'Growth velocity' defines the rate of growth or change in growth measurements over a period of time.

Figure 2.2 Visual feedback on child's growth monitoring status on the mobile phone screen

Note: Green (top left)=normal weight; yellow (top right)=mild underweight; red (bottom left)=moderate to severe underweight; violet (bottom right)=overweight.
Source: World Vision Indonesia.

During growth monitoring, the child's nutritional data are saved on the mobile phone and then submitted via general packet radio service (GPRS) to the cloud-based, password-protected server.

2.2 The context: community-based growth monitoring in Indonesia

Despite steady economic growth, child undernutrition has declined only gradually in Indonesia (Haddad *et al.* 2015). According to the RISKESDAS National Basic Health Survey reports from 2010 and 2013, there was even a slight increase in the prevalence of both underweight (from 17.9 to 19.6 per cent) and stunting (from 35.6 to 37.2 per cent) among children under five (National Institute of Health Research and Development, M.o.H.I. 2013). At the same time, the proportion of overweight children is rising rapidly, to 11.5 per cent in 2013 (Haddad *et al.* 2015). Routine growth monitoring of children below five years of age is an integral part of the essential nutrition services of the Indonesian Department of Health (Widjojo *et al.* 2014). It aims to detect children at risk of undernutrition early on and trigger interventions to prevent further decline in nutritional status.

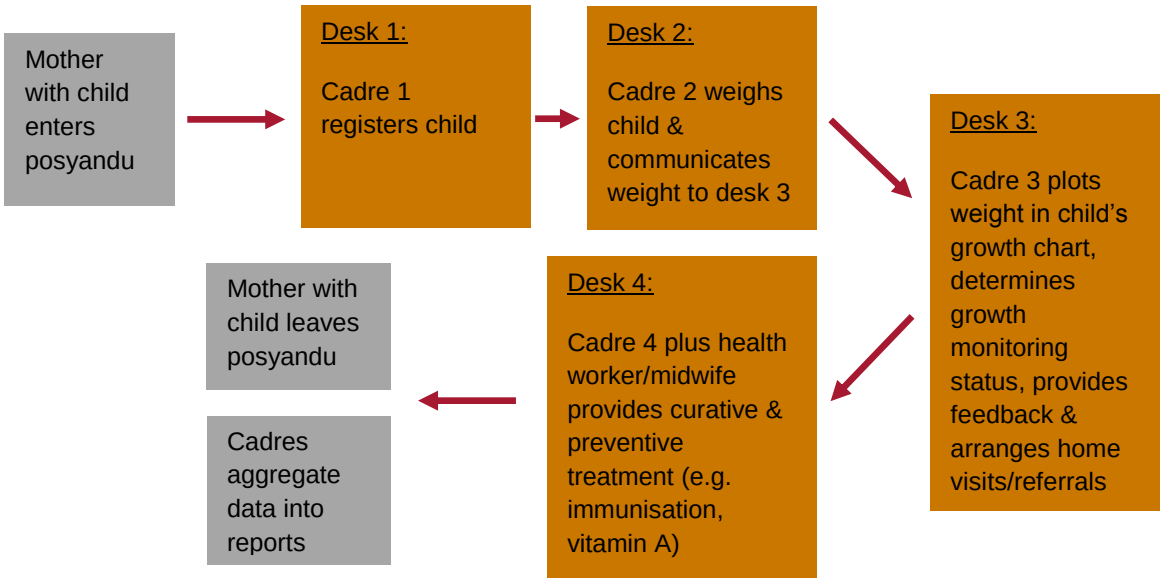
Growth monitoring in Indonesia is delivered through the posyandu system.[5] Posyandus provide basic health and nutrition services to communities (Sulistyorini, Pebriyanti and Proverawati 2010). They are supported by the district health offices (via funding from the Ministry of Health), the Ministry of Internal Affairs and Family Empowerment and Welfare (FEW).[6] Posyandus are run monthly by local community volunteers (cadres) with the support of a local midwife and/or health officer. They are usually conducted at a central place (e.g. in a house provided by the community) in urban as well as rural communities.

For the purpose of this evaluation study, a mobile phone application was integrated into the growth monitoring activities in the posyandus. Growth monitoring across Indonesia follows a predetermined procedure with several successive tasks. Each task is ideally performed by one cadre at one of the desks (also called stations). All growth monitoring activities currently use paper-based systems (e.g. registration books for the children attending, reports and growth charts). Data collected as part of growth monitoring activities are aggregated by the cadres and compiled into different reports that are sent to sub-district-level health authorities

[5] Community-based growth monitoring has been implemented nationwide in Indonesia since the 1980s.
[6] Government-led welfare movement.

and other relevant stakeholders. Figure 2.3 describes the different tasks the cadres perform (as observed during the evaluation team's initial field visit in February 2014).[7]

Figure 2.3 Growth monitoring procedure in the posyandus (as observed during the initial field visit)



Note: Cadre 2 only assesses weight. Height measurements have just been introduced to the posyandu, but are conducted by health workers once or twice a year only.

Source: Authors' own.

2.2.1 Current challenges for nutrition monitoring in Indonesia

Several recent studies (Haddad *et al.* 2015; Sulistyorini *et al.* 2010; Anwar *et al.* 2010; Freidman *et al.* 2006; Khomsan *et al.* 2014; Nazri *et al.* 2016; Sinaga and Manalu 2015; Wisnuwardani 2012), a review of the nutrition sector by the Ministry of Health (Widjojo *et al.* 2014; Indonesia, Ministry of Health 2014) and the evaluation team's field visit in February 2014 highlighted several challenges to the implementation of growth monitoring through the posyandu. Cadres' poor skill levels and levels of standardised knowledge represent a major shortcoming, mainly caused by the poor support and supervision they generally receive. There are also huge variations in the capacity of cadres and, consequently, in the quality of growth monitoring across districts (Indonesia, Ministry of Health 2014). One reason for this variation might lie in the decentralisation of all government services, which was implemented in 2000. This saw responsibility and accountability for nutrition services shift from central to district level.

Other challenges include poor quality of growth monitoring data that are collected, long delays between data collection and submission, and low responsiveness of cadres to the data (e.g. by providing feedback to caregivers/mothers (hereafter referred to as mothers) on the growth monitoring status of the child; if feedback was provided to the mother, it often was not understood or accepted by her). Mothers' satisfaction with the services they received in the posyandu was frequently low, as was attendance (Nazri *et al.* 2016).

[7] The observed procedures diverted slightly from the growth monitoring procedures recommended by the Ministry of Health. According to Ministry guidelines, cadre 3 is supposed to plot the child's growth, cadre 4 is supposed to provide feedback and cadre 5 provides curative and preventive treatment. However, in reality, desk 4 is non-existent in most posyandus; feedback and referrals/appointments are provided by cadre 3, as depicted in Figure 2.3.

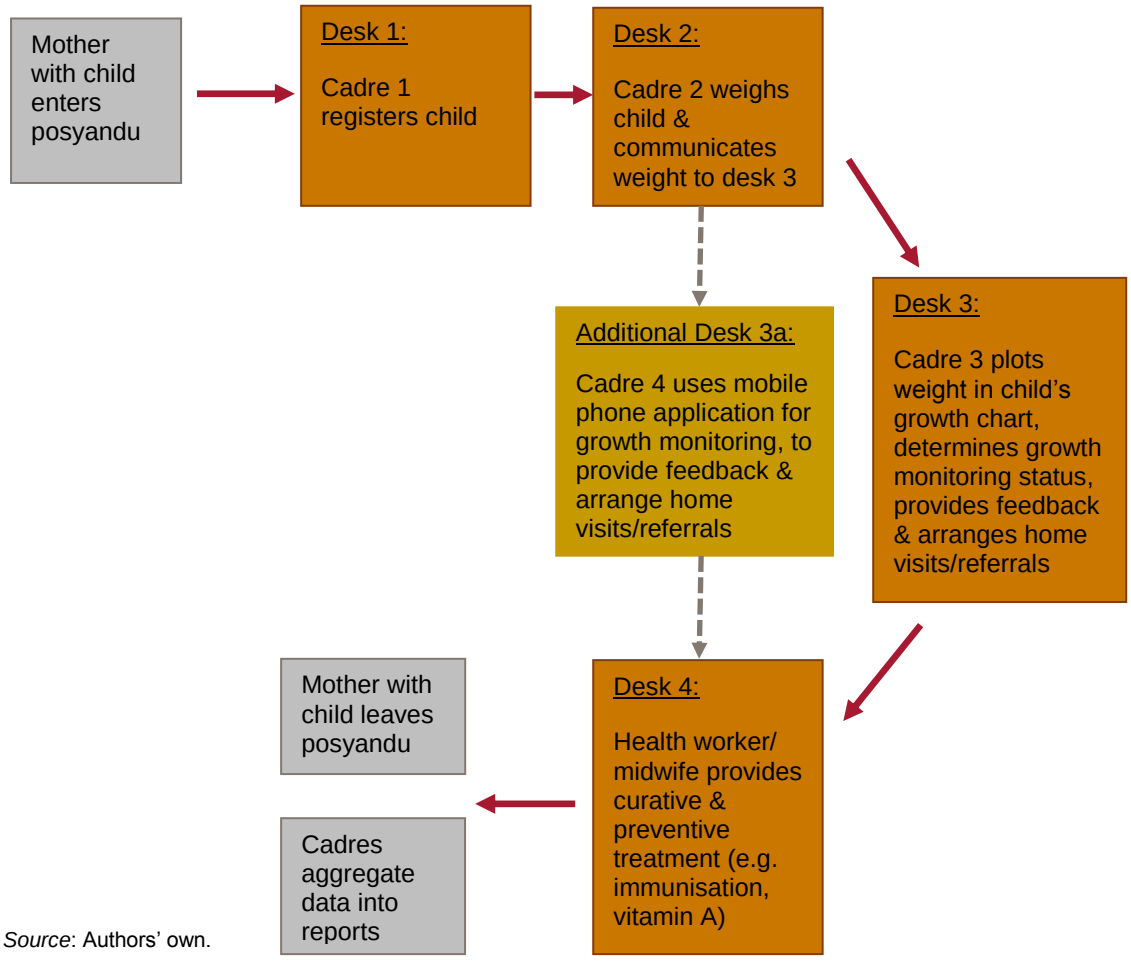
The mobile phone application seeks to address these challenges by providing support to the cadres and aiming to improve growth monitoring accuracy and timeliness, and its responsiveness to the data.

2.3 Integration of the mobile phone application into the posyandu

Figure 2.3 describes the monthly growth monitoring procedures in the posyandus and the activities of the four cadres. For the purpose of this evaluation study, the mobile phone application was integrated into the existing nutrition monitoring activities through the posyandu for a period of 12 months. Each posyandu included in the pilot received one mobile phone with the application. To avoid drastic changes in the traditional paper-based growth monitoring system and to minimise the burden on cadres, the evaluation team moved cadre 4 to a newly established desk (3a) for this pilot study. This means that cadre 4 became cadre 3a for the pilot and evaluation study. This was possible as desk 4 was staffed by a cadre and a health worker/midwife. Cadre 3a would be responsible for the mobile phone and would conduct the growth monitoring on the phone. Desks 3 and 3a were located immediately next to each other and the mother approaches the two desks at the same time. Figure 2.4 describes the process.

Several cadres in each posyandu were trained to use the mobile phone application.

Figure 2.4 Growth monitoring procedure in the posyandu with mobile phone application integrated (cadre 4 is moved to desk 3a)



Source: Authors' own.

3 Evaluation approach and methods

This section provides an overview of the approach and methods used for the evaluation. It starts with a description of the theory of change (ToC) that formed the conceptual underpinning of the evaluation design, followed by the detailed evaluation questions and the sampling approach used. It continues by detailing the context-specific evaluation approaches that were developed to assess the impact of the mobile phone application on accuracy, timeliness and responsiveness to growth monitoring data. It then describes the data collection methods, data synthesis and analysis. It finishes by discussing ethical considerations, the main implementation challenges the team faced, and limitations of the findings.

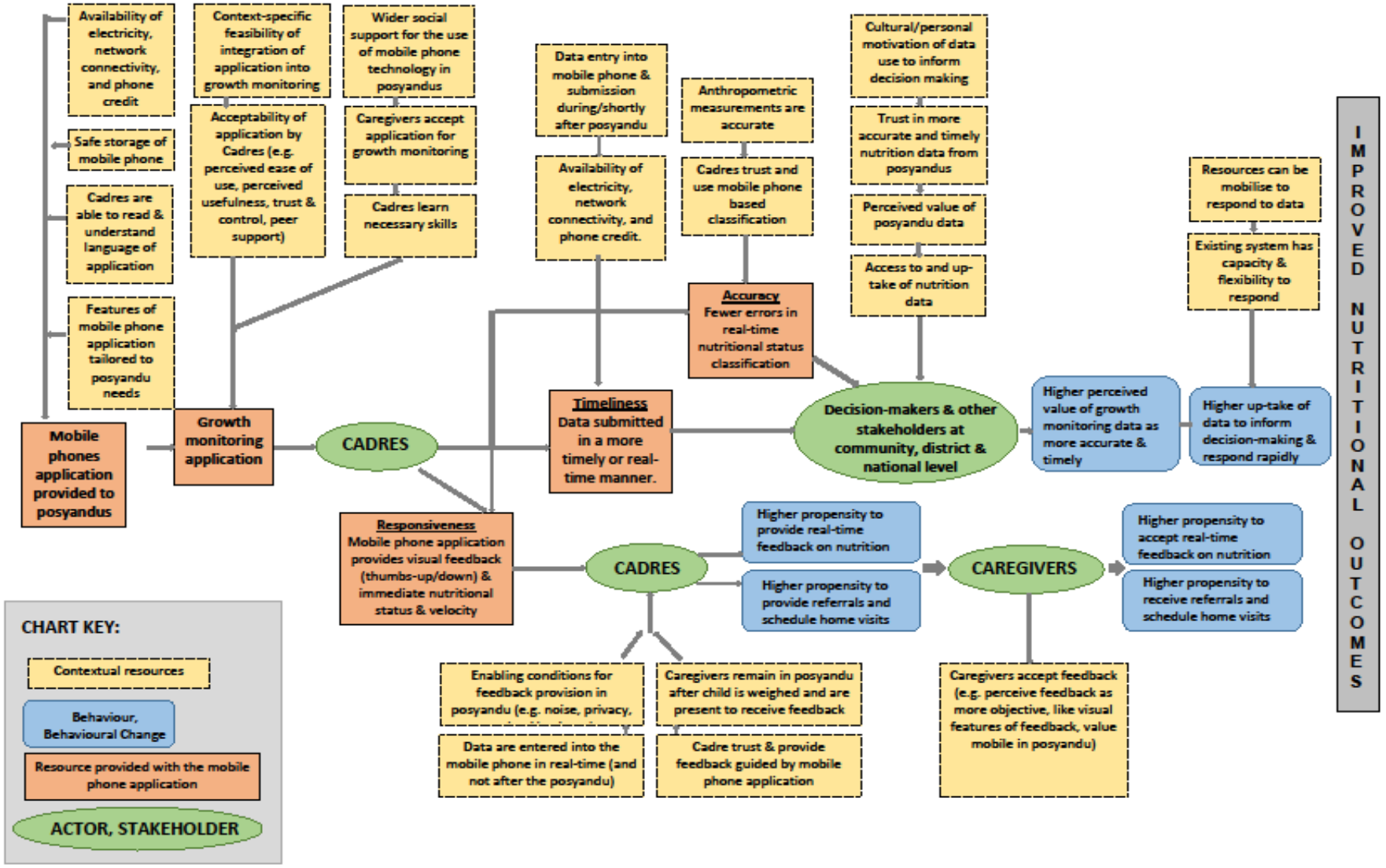
3.1 Theory of change (ToC)

This evaluation used a theory of change (ToC) approach to map the anticipated process of change and explain how the mobile phone application is expected to bring about an improvement in growth monitoring and more specifically to the accuracy, timeliness and responsiveness of growth monitoring. The ToC also guided the development of detailed evaluation questions, and facilitated data analysis and reporting. The team developed the initial draft of the ToC in the planning stage of the evaluation, in consultation with key stakeholders at community and district level, and informed by a field visit conducted in February 2014. The ToC was revised and further developed based on findings from the formative phase (see report from the formative phase published previously – Barnett *et al.* 2016).

Figure 3.1 presents the ToC underlying this impact evaluation. It suggests that the features provided by the mobile phone application can: (1) improve accuracy; (2) improve timeliness of the growth monitoring data, which may then increase the perceived value and use of the data to inform decision-making for nutrition; and (3) positively influence cadres' practice of providing real-time feedback to mothers and arrange home-based counselling or referral if necessary. The ToC maps contextual conditions (e.g. availability of electricity/connectivity, posyandu features and procedures); it also maps motivations and practices of cadres (e.g. acceptability of and trust in the mobile phone application, whether data entry takes place during the posyandu), of mothers (e.g. trust in growth monitoring status classification by mobile phone, presence for feedback) and decision-makers (e.g. perceived value of data, capacity to respond, readiness to respond to real-time data), all of which influence whether the mobile phone application can bring about the desired change.

In the following section, the details of how the mobile phone application may improve accuracy, timeliness and responsiveness will be explained, followed by the resulting evaluation questions.

Figure 3.1 Theory of change for evaluation of mobile phone application for growth monitoring in the posyandus



Source: Authors' own.

3.2 Accuracy assessment

The production of accurate data is essential for effective growth monitoring and management of the growth monitoring status of children at community level (Mangasaryan *et al.* 2011; Ashworth *et al.* 2008). Doubts about the accuracy of growth monitoring data have been identified as a major reason why data are not taken up by local, regional and national policymakers to inform nutrition-related decision-making – for example, when allocating resources for nutrition services (Mangasaryan *et al.* 2011). During the field visit to the posyandus, low accuracy of growth monitoring status plotting and interpretation of growth curves was identified as a major threat.

To assess a child's growth monitoring status and velocity,[8] cadre 3 needs to plot the anthropometric measurements of the child on the growth chart and interpret the child's pattern of growth based on the growth chart. Incorrect plotting can result in misclassification of the child's growth monitoring status, with potentially severe consequences (e.g. an undernourished child is wrongly categorised as normal weight) and can also lead to misdirection of limited resources (Mangasaryan *et al.* 2011).

The mobile phone application prevents misclassification due to incorrect plotting by employing an automated script to calculate growth monitoring status by comparing the weight and age of the individual child with international World Health Organization (WHO) reference values.

The resulting specific evaluation question was:

1. How much did the mobile phone application improve accuracy of growth monitoring status calculation and classification during the monthly posyandu compared to the traditional paper-based system?

3.3 Timeliness assessment

Timely submission of growth monitoring data to local- and district-level authorities is important to inform decision-making – for example, in terms of resource allocation to the posyandus, and facilitating responsiveness to sudden events that can have an impact on the growth monitoring status of children (e.g. an increase in diarrhoeal diseases or malaria after flooding). Data submission in traditional paper-based systems is often very time-consuming as the data forms need to be transported and manually entered into an electronic database. Further work (and additional time) is needed to aggregate data before submission, as is the case in the posyandu system. During our field visit, we learned that cadres are required to send up to 12 summary reports to various higher-level health facilities and authorities, including local midwives, the village health post, sub-district health centre, Family Empowerment and Welfare (FEW) group, and urban employment authorities (in urban areas mothers are asked about their employment status as part of the posyandu procedures).

The mobile phone application has the potential to increase the timeliness of data submission as data can be uploaded in real time to a central server. However, real-time data submission requires network connectivity at or close to the posyandus to be available.

[8] Definition of growth velocity: the rate of growth or change in growth measurements over a period of time, based on weight, height and age measurements.

The specific evaluation question was:

2. How much did the mobile phone application improve the timeliness of submission of aggregated nutrition data to the sub-district authorities after the monthly posyandu compared to the traditional paper-based system?

3.4 Assessment of responsiveness to the data

3.4.1 Provision of feedback

An important element of effective community-based growth monitoring is to raise caregivers' awareness of the growth monitoring status of the child, reassure and empower them to track the child's nutritional health, and take adequate actions to improve in case growth faltering is detected (Mangasaryan *et al.* 2011).

Cadre 3 at desk 3 is meant to plot and classify growth monitoring status, interpret the individual growth chart and provide immediate feedback to the mother on the child's growth monitoring status and velocity. Feedback could include giving brief reassurance to the mother that the child is doing well, or highlighting an existing problem in cases where growth faltering is detected.

The literature suggests that nutrition feedback provision (and nutrition counselling) in the posyandus has declined considerably during recent decades mainly due to a lack of training for the cadres (Widjojo *et al.* 2014; Sulistyorini *et al.* 2010). The evaluation team's observations of the posyandu procedure confirmed this, and interviews with mothers in the posyandus suggested that real-time feedback (either reassurance or highlighting a problem) is rarely provided. In focus group discussions, the cadres explained that they felt uncomfortable telling a mother that her child is not doing well because mothers tended to be offended and react defensively. Negative feedback was perceived by mothers as publicly blaming and shaming them for not taking care of the child properly.

In this context, the cadres pointed out that the mobile phone application may positively influence their propensity and willingness to provide immediate feedback, including highlighting nutritional problems. Feedback based on the growth monitoring status classification provided by the mobile phone was perceived as a more objective third-party assessment and less like the subjective opinion of a cadre. Cadres expected that mothers may be less likely to challenge and be offended by this feedback.

The specific evaluation questions were:

3. How much and why did the mobile phone application increase the propensity to provide real-time nutritional feedback during the monthly posyandu compared to the traditional paper-based system?

   What are the relative percentages of mothers provided with real-time feedback on the growth monitoring status and velocity of the child with and without the mobile phones?

3.4.2 Set up of home visits and referrals

Home-based counselling to promote good childcare and feeding practices has been shown to be effective in improving child nutrition (Morrow *et al.* 1999; Bhandari, Kabir and Salam 2008; Lutter 2013). Counselling at home allows the cadre to assess feeding and childcare practices, provide tailored behaviour-change messages, and discuss new behaviours with the caregiver. During the posyandu procedures, cadre 3 is responsible for setting up home

visits or (in case of severe undernutrition) referral to the health facility for treatment and rehabilitation. Individual-level nutrition counselling is not feasible during the often very busy and overcrowded posyandu days. The arrangement of individual home visits is essential, but is often neglected or is conducted in a haphazard manner.

Mobile phones can potentially increase the percentage of undernourished children that are followed up and receive referrals or home-based counselling following the posyandu. The application will send an automatic message to cadre 3a, highlighting the need for a home visit or referral, and will also guide the selection of a day and set-up of an appointment.

As with the feedback provision, cadres are likely to feel more comfortable setting up appointments as they might feel 'authorised' by the message sent via the software and not based on their own assessment and calculations following the plotting of the growth chart.

The evaluation was guided by the following questions:

4. How much does the mobile phone improve the propensity to arrange a home-based counselling session or referral during the posyandu visit?

   What were the relative percentages of undernourished children followed up and receiving an appointment for home-based counselling or referral to the health facility following the posyandu, with and without the mobile phones?

3.5 Summary of evaluation questions

The resulting evaluation questions were:

1. Accuracy assessment:

How much did the mobile phone application improve accuracy of growth monitoring status calculation and classification during the monthly posyandu compared to the traditional paper-based system?

2. Timeliness assessment:

How much did the mobile phone application improve the timeliness of submission of aggregated nutrition data to the sub-district authorities after the monthly posyandu compared to the traditional paper-based system?

3. Responsiveness to data assessment:

How much and why did the mobile phone application increase the propensity to provide real-time nutritional feedback during the monthly posyandu and compared to the traditional paper-based system?

How much does the mobile phone improve the propensity to arrange a home-based counselling session or referral during the posyandu visit?

3.6 Sampling of the study sites

This evaluation used an explanatory multi-site case study method to examine the impact of the mobile phone application on growth monitoring (Morra and Friedlander 1999). The study sites (i.e. posyandus) were purposefully selected by the World Vision team prior to the start of the evaluation and could not be changed by the evaluation team. The evaluation took place in all selected pilot sites. Selection criteria included proximity to major roads (to enable

easy access), access to electricity (important to be able to charge the mobile phone) and existing partnerships between the posyandu and the local World Vision Indonesia team.

The evaluation took place in urban Jakarta and rural sites in Sikka located in East Nusa Tenggara province (in Indonesian: *Nusa Tenggara Timur – NTT*) in the eastern part of the Lesser Sunda Islands (see Figure 3.2).

Figure 3.2 Location of evaluation sites in Indonesia

Source: Authors' own

A total of 14 study sites had been selected in three areas of Indonesia, two urban and one rural, comprising, respectively, two, two and ten posyandus (Figures 3.3 and 3.4). The posyandus in Sikka were located in four large villages with several posyandus in each village to serve the population. Village 1 has two posyandus, village 2 has two posyandus, village 3 has three posyandus and village 4 has three posyandus.[9]

Figure 3.3 Evaluation sites in Jakarta

Source: Authors' own.

[9] To ensure anonymity of the communities, children and posyandus included in this study, names and locations are kept confidential. Further general information on the study sites is available on request from the authors.

Figure 3.4 Evaluation sites in Sikka

Source: Authors' own.

3.7 Evaluation approach

The choice of evaluation approach was influenced by two context-specific challenges/opportunities discussed above:

1. The 14 study posyandus for this evaluation had already been selected by the World Vision team prior to the evaluation and could not be changed (see Section 3.6);
2. It was impossible to replace the paper-based growth monitoring in the posyandus with mobile phone-based growth monitoring due to the statutory reporting obligations of the posyandus to local- and district-level health offices and other stakeholders. Consequently, the mobile phone application needed to be introduced in parallel to the existing paper-based growth monitoring in the posyandu (see Section 2.3).

As a result, it was impossible to use common causal inference models for impact evaluation, including RCTs, conventional quasi-experiments and natural experiments. However, the unique setting offered the opportunity to use a counterfactual design based on the same causal inference logic: Mill's Method of Difference.

3.7.1 Mill's Method of Difference for accuracy and timeliness assessment

Mill's Method of Difference provides the basic underlying logic of most counterfactual designs (including RCTs, case-control studies) (Cartwright and Munro 2010; Reiss 2015). Mill's Method of Difference is usually not identified as an experimental design as there are no separate treatment and control groups. Instead, the same group receives both treatment and non-treatment and produces separate outcomes following each of these simultaneous procedures (see Figure 3.5) (Stern *et al.* 2012).

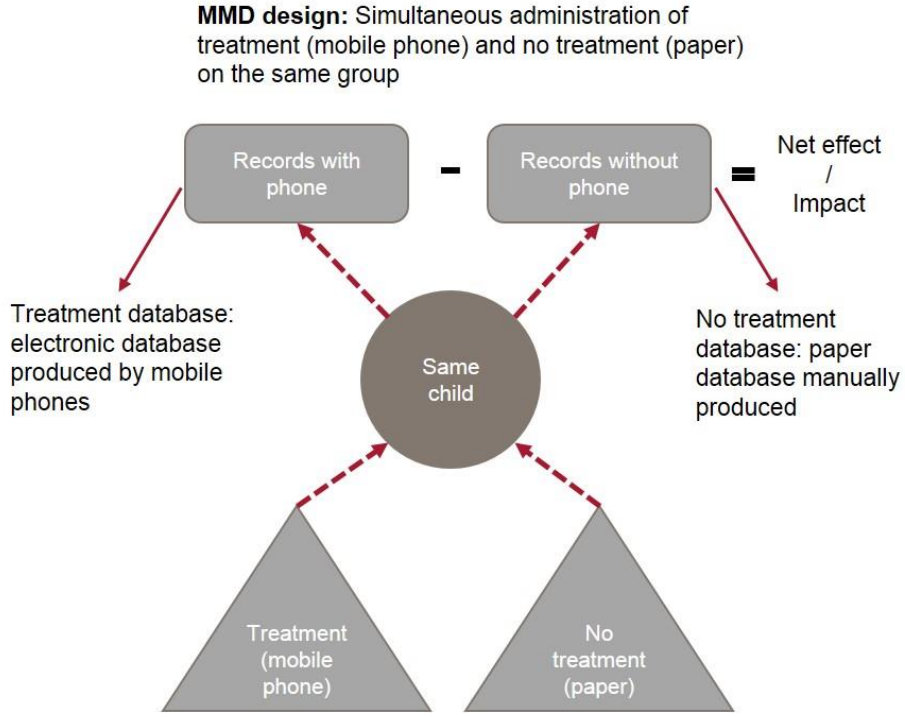
For this impact evaluation, this means that mobile phone-based and paper-based growth monitoring are applied simultaneously to the same population of children by cadre 3 (paper) and 3a (mobile) and generate separate electronic and paper-based outcomes (i.e. electronic and paper-based records with the child's growth monitoring status classification, time records of data submission, feedback and, if necessary, appointment for counselling or referral). In practice, this means that the mother with child goes from desk 2 directly to desks 3 and 3a, which are immediately next to each other. Cadres 3 and 3a then calculate the child's growth monitoring status simultaneously and have the same opportunity to provide feedback based on their calculations. Any difference in the outcomes cannot be attributed to any plausible cause other than the different performances of the two technologies (see Figure 3.5). Difference in the outcomes cannot be attributed to the differences between two populations (as in treatment and control groups) because the two procedures are applied to the same

population. Difference also cannot be attributed to different contextual conditions present at different administration times, because the two procedures are applied simultaneously.

Positions of cadres 3 and 3a and mother during the posyandu. *Source*: © World Vision Indonesia (2015).

To control for the potential influence of characteristics of the cadres at desks 3 and 3a, cadres at desk 3a alternated throughout the evaluation period and desk 3 was staffed by the cadre with the best plotting skills in the posyandu (as determined by the other cadres at the beginning of the evaluation).

Figure 3.5 Mill's Method of Difference design used for the impact evaluation of mobile phone technology



Source: Authors' own.

In practice, this means that the impacts of the mobile phone application on accuracy and timeliness of growth monitoring were calculated by comparing the two resulting databases – one obtained with the mobile phones and the other obtained with the paper-based system. The difference in the effects can only be attributed to the differential effectiveness of the paper- and mobile phone-based systems.

To contextualise the findings on accuracy and timeliness, quantitative and qualitative data from the contextual analysis, the acceptability assessment and focus group discussions with the cadres and mothers were used to complement the findings. This will help to inform further development of the programme and the potential transfer of the mobile phone application to other settings in Indonesia and globally.

3.7.2 Mill's Method of Difference and realist evaluation for the responsiveness assessment

Mill's Method of Difference

The same comparative causal inference design based on Mill's Method of Difference was used to assess the impact of the mobile phone on responsiveness. For this, an observer was present during the posyandu day to continuously record cadres' practices and behaviours in providing real-time feedback and arranging appointments as they occurred. Directed by a structured observation protocol/checklist, the observer systematically noted whether feedback was given and home visits/referrals were arranged by the cadres with or without the mobile phone. The observer also collected data on other dynamics related to the responsiveness to growth monitoring.

For the different design options to be robust, all mothers should have the same probability of receiving feedback from the cadre 3a (using the mobile phone) and the cadre 3 (using pen and paper). In order for this to happen, the physical location of the different desks and cadres in the posyandu centre and proximity of the mothers to the cadres with and without mobile phone needed to be carefully considered. It was important that anthropometric data from desk 2 was communicated to both the cadres with and without a mobile phone. Interactions between the cadres with and without a mobile phone needed to be kept to a minimum (see also growth monitoring component), and guidelines provided to the cadres with and without a mobile phone needed to be identical (e.g. cadres with a mobile phone should receive the same level of encouragement and guidance with regards to the provision of nutrition feedback as cadres without a phone).

Additional to the direct observations, exit interviews with a random sample of mothers and focus group discussions with cadres were conducted immediately after the posyandu to gain multiple perspectives into how the mobile phone application may influence the provision of feedback and the arrangement of home visits/referrals. For the mothers, short surveys were used to collect information on the provision of real-time nutrition feedback, set-up of home visits and whether a cadre with or without a mobile phone conducted these tasks. The survey also collected data on the caregiver's overall experience of the posyandu day and her/his perceptions, observations and experiences of the mobile phone throughout the process. An exit interview with the mothers was less intrusive, although there was the risk of interviewer and social desirability bias (e.g. mothers may reply in a manner they think is expected – for example, they praise the benefits of the phone).

Realist evaluation

To examine the underlying mechanisms that may lead to increased responsiveness and identify 'what works, how, for whom and under what circumstances', a realist evaluation approach was employed (Pawson and Tilley 1997). Based on the findings from the field visits in 2014, discussions with the World Vision field team, review of the literature and context

analysis during the formative phase, initial theories about how and in which conditions the mobile application may increase responsiveness of the cadres were developed, in the form of context-mechanism-outcome (CMO) configurations.

Qualitative and quantitative data collection tools were then adapted to gather information needed to test and further develop the initial CMOs. During the data analysis phase, the initial CMOs were tested and modified using both quantitative and qualitative data collected during the summative phase of the evaluation. This has resulted in a refined and evidenced set of CMO configurations, which provide an insight into how and why a mobile phone application can contribute to increased responsiveness in the form of cadres being more likely to provide feedback to mothers.

3.8 Data collection

Qualitative and quantitative data collection took place using the following tools and methods. The evaluation consisted of an initial formative phase that aimed to assess the acceptability of the mobile phone application, collect information on the context and test the functionality of the mobile application (months 1–3 of the pilot). There was also a summative phase that focused on the assessment of the impact of the mobile application on timeliness, accuracy and responsiveness (months 4–12 of the pilot).

3.8.1 Routine data collection

Paper-based records (including temporary paper slips that were used by cadre 2 to transfer the anthropometric measurements to desks 3 and 3a, and aggregated summary reports) of all growth monitoring data (either as copy or originally) were collected by the evaluation team from all study posyandus every three months. To assess timeliness, cadres, midwives and sub-district health officers were also asked to keep records of time and date of submission and reception of aggregated summary reports in a standardised diary distributed at the start of the pilot. Self-reported time records were checked for completeness and collected by the evaluation team every three months. All paper-based records and time recording sheets were scanned and entered into Excel sheets by data entry staff in Jakarta and Sikka. Electronic databases of the growth monitoring data were downloaded from the server.

3.8.2 Structured direct observation

A structured observation protocol with a checklist aided the systematic recording of behaviours, feedback-giving practices and who arranged home visits or referral during the growth monitoring session. The direct observer collected observation data for all children that were measured during the posyandu session. Seven[10] growth monitoring sessions per posyandu were systematically observed.

There were several potential threats that could affect the accuracy and validity of the data collected via direct observation during the posyandus. These include: (1) reactivity, meaning the cadres react to the presence of the observer and change their behaviour accordingly; (2) observer drift, which describes a gradual shift of the attention of the observer that can result in inconsistencies in the recording of the observed target behaviours (i.e. provision of feedback and arrangement of home visits); (3) errors during the recording procedures – for example, because the observer gets distracted by other activities during the posyandu or has problems hearing the cadres due to background noise (e.g. crying or playing children, laughing caregivers); (4) observers' expectations of the cadres' behaviours and the benefits of the mobile phone technology; (5) challenges to inter-observer reliability – for example, if different observers collect data at the same posyandu centre and during different posyandus; and (6) characteristics of the observer (e.g. gender, status, relation to World Vision, the local community) and the cadres (e.g. age, socioeconomic status, status in the local community)

[10] Due to the time requirements it was impossible to observe all 12 sessions in each posyandu.

(Repp *et al.* 1988). To address these threats and increase the accuracy of the observations, a number of steps were taken: all observers were trained meticulously; there was an initial 'adaptive period' during the formative period for cadres and observers to become familiar with each other and to reduce the risk of reactivity (observations from the formative phase were not included in the impact analysis); and the set-up for the observation was as unobtrusive as possible (observer was located behind the desks of the cadres).

3.8.3 Focus group discussions with cadres

Focus group discussions (FGDs) with all cadres were conducted during the initial formative phase of the pilot in months three, six and twelve. FGDs were conducted in each posyandu and with all cadres working in the posyandu (n=74). FGDs in month three aimed to explore the acceptability of the mobile phone application by the cadres for growth monitoring. Further details can be found in the formative phase report published previously (Barnett *et al.* 2016). Briefly, the acceptability assessment focused on: perceived ease of use and perceived usefulness of the mobile phone application; trust in and perceived control over the application; and peer support and wider social support for using the application for growth monitoring in the posyandu.

FGDs in month six aimed to gain insights into cadres' experiences, perceptions and challenges when using the mobile phone application for the growth monitoring during the posyandu. The FDGs also explored how and in which specific contexts the technology may influence cadres' behaviours with regards to the provision of 'real-time' feedback and arrangement of home visits or referrals. The final FGDs examined cadres' perceptions, opinions and views on the mobile phone application after using it for 12 months for growth monitoring in the posyandu. Focus groups used semi-structured topic guides and lasted around 60 minutes per posyandu. All focus groups were audio-recorded, transcribed verbatim and translated into English. A note-taker (additionally to the interviewer) also recorded non-verbal comments and observations during the interview.

3.8.4 Exit interviews with mothers

The exit interviews aimed to collect information on mothers' experiences, perceptions and observations of the mobile phone for the posyandu growth monitoring activities. It also collected data on the provision of real-time feedback to the mother and whether it was given by the cadre with or without a phone. Exit interviews were guided by a short structured questionnaire and took approximately ten minutes. Exit interviews were conducted with a random sample[11] of mothers as soon as they left the posyandu and throughout the entire posyandu session. For mothers who brought two or more children to the posyandu, exit interviews were conducted separately for each child. The exit interviews were conducted during the summative phase and during three growth monitoring sessions in each posyandu.

To reduce the risk of reactivity by the cadres, the exit interviews were conducted outside the posyandu or somewhere where the cadres could not overhear the interview.

3.8.5 Context protocol

The context protocol assessed contextual factors and organisational factors that may interact with the use and functionality of the mobile phone application for growth monitoring and nutrition counselling. It guided the collection of data on the characteristics of the cadres, cadres' attitude towards mobile phones for posyandu activities, features and work flows of the posyandu, network coverage/stability and access to electricity, environmental context and security concerns (e.g. theft). The context protocol was administered during the

[11] To achieve a random sample the interviewer was located at the entrance of the posyandu and conducted the first interview with one of the first mothers that left the posyandu. As soon as the interview finished, the interviewer approached the next mother who exited the posyandu the second the interviewer looked up, and so forth.

formative phase in month three of the evaluation in a meeting with all cadres and all health workers (responsible for the respective posyandu) in each posyandu at the beginning of the pilot (during the formative phase). The protocol also included several observations (e.g. noise levels during posyandu) to be conducted by the interviewer. A full analysis of the context protocol can be found in the formative evaluation report published previously.

All data collection tools were tested in both rural and urban sites during the formative phase of the pilot. Necessary modifications of the tools were carried out. The tools were translated into the Indonesian language by a professional translator and translations were checked by the evaluation team during the training workshop prior to data collection.

3.9 Timeline of data collection

Table 3.1 presents the timeline for the data collection. Data were collected from all posyandus and using all tools listed. Data collection took place on an ongoing basis between January 2015 and January 2016. A 12-month pilot was considerably longer than the time frame used in other studies on the use of mobile phone technology for nutrition (Barnett and Gallegos 2013). The reason for the longer period for this evaluation was that we aimed to assess the mobile phone's impact once the initial enthusiasm and novelty had worn off (Andreassen, Kjekshus and Tjora 2015).

Table 3.1 Timeline for data collection events for each posyandu

	Months of the pilot											
	Formative evaluation			**Impact evaluation**								
Data collection tool/s	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Routine data collection[a]												
Structured direct observations[b]												
FGDs with cadres												
Exit interviews with mothers												
Context protocol[c]												

Notes: [a] For analysis only data from months 4, 7 and 10 were used; [b] For analysis only data from months 4, 5, 6, 8, 10 and 12 were used. [c] Data to complement and contextualise impact evaluation of mobile phone application for growth monitoring, for full analysis see formative evaluation report (Barnett *et al.* 2016).

3.10 Data analysis

3.10.1 Quantitative data analysis

All paper-based records, questionnaires and the context protocol were entered into Excel databases by data managers in Jakarta and Sikka. Cross-checks for accurate data entry were conducted for all posyandus by the evaluation lead in Jakarta. Data checking and cleaning (including range checks, consistency checks, dealing with missing values and matching) was performed by both the data managers in Jakarta and Sikka. A second round of data checking was carried out by the data managers in IDS.

The impact of the mobile phone on the accuracy of classification of growth monitoring status was determined by comparing classifications based on pen and paper with those conducted by mobile phone at the level of the individual child for three monthly posyandus (months four, seven and ten of the pilot) in each site (the analysis covered 13 out of 14 sites, as mobile phone-based data from posyandu 01 in Sikka were lost due to technical problems with the server and were not included in the analysis). A total of 1,041 paper- and mobile phone-

based records were matched successfully. Excluded from comparison were pairs with different or missing body weight measurements (n=110) and missing growth monitoring status (n=184),[12] leaving 747 matched records for analysis. Misclassification frequencies and rates and improvement in classification with the phone were calculated for each posyandu site and overall. Median and mean improvement rates were determined, stratified by urban and rural sites, and statistical significance was tested. Chi-squared tests for categorical variables and t-test for continuous variables were used to examine the association between cadres' characteristics (namely age, education) and accuracy improvement rates.

Timeliness of nutrition reporting by the conventional paper-based system was compared with those reported by mobile phone for three monthly posyandus (months four, seven and ten of the pilot) in each of the 13 study sites (n=52) (mobile phone-based data from posyandu 01 in Sikka were lost due to technical problems with the server and were not included in the analysis). Median time lags between data collection in the posyandu and data access at sub-district level was calculated for each posyandu site. Mean time lags were determined overall and stratified by urban and rural sites. Statistical significance tests were conducted and associations with cadres' and posyandus' characteristics were tested.

The impact of the mobile phone on responsiveness by the cadres was determined by comparing the proportion of mothers who received feedback, appointments or referrals with and without the mobile phone. Analysis was conducted at the level of the individual child. A total of 3,306 observation records were collected from six growth monitoring sessions per posyandu (months four, five, seven, nine, ten and eleven) in each of the 14 study sites. Excluded from analysis were observation records in which cadres 3 and 3a did not receive the child's anthropometric measurements at the same time and records in which cadres 3 and 3a communicated with each other about the child's nutritional status, leaving 2,399 observation records (Table 3.2). Also excluded were records in which both (with and without phone) cadres provided feedback (n=123). The remaining 2,276 records were used for analysis.

Table 3.2 Observation records on feedback provision included in the analysis

	Did cadres communicate with each other?		
Did cadres receive child's measures at the same time?	No N,%	Yes N,%	Total N,%
No	379 (13.6)	93 (14.3)	472 (13.8)
Yes	2,399 (86.4)	558 (85.7)	2,957 (86.2)
Total	2,778 (100)	651 (100)	3,429 (100)

Relative percentages of feedback provision, appointment setting or referrals by mobile phone and mean rates were calculated overall and stratified by urban and rural sites. Statistical significance was tested and associations with cadres' and posyandus' characteristics were tested. Findings from the observation protocols were triangulated with quantitative descriptive analysis of the exit interviews with caregivers. A total of 519 exit interviews were conducted during six growth monitoring sessions in each posyandu (months four, five, seven, nine, ten and eleven) in all 14 study sites.

Descriptive statistics was carried out with the data collected from the context protocol and in the exit interviews. Analysis of the quantitative data was done in STATA, version 13 (StataCorp, College Station, Texas).

[12] Illegibility of the weight measurement on the paper records was the main reason for missing nutritional status records.

3.10.2 Qualitative data analysis

Qualitative FGDs were audio-recorded, transcribed and translated from Indonesian to English. Field notes from the interviews were also translated. A data-driven content analysis approach was employed (Elo and Kyngäs 2008). In accordance with the aims of the evaluation, the analysis was focused on cadres' acceptability, perceptions, views and experiences with using the mobile phone application for growth monitoring activities in the posyandu. The analysis started with a check of the transcripts of the interviews to ensure accuracy. Analysis of the FGDs conducted in months three, six and twelve was done separately. For each qualitative data collection round, each FGD transcript was read several times to permit familiarisation with the data and to identify initial patterns. Three transcripts were read carefully line-by-line and initial codes were developed. After this open coding, an initial coding scheme was developed that guided the coding of the remaining transcripts. In the process, codes were repeatedly modified or combined and parts of transcripts were recoded. Codes were then sorted into emerging categories based on relations and interlinks. These categories were further combined into hierarchical structures if possible. Open codes were summarised into emerging themes. Data from the field notes were used to further inform the development of codes and categories. NVivo software was used to facilitate the coding.

3.10.3 Integration of quantitative and qualitative data

Qualitative and quantitative data were integrated to further explain, triangulate and contextualise the accuracy, timeliness and responsiveness assessment. An iterative approach was used to combine qualitative and quantitative findings and gain deeper insights into the impact of the mobile phone technology and also to capture potential unintended consequences of the mobile phone (Rao and Woolcock 2003).

3.10.4 Data analysis for realist component

The analysis for the realist component of the impact evaluation was carried out in several subsequent phases. In phase 1, quantitative and qualitative data were organised based on the contexts, mechanisms and outcomes guided by the initial CMOs. The starting point for the organisation was the outcome patterns observed (i.e. the difference in the provision of feedback by mobile phone compared to no mobile phone, disaggregated by evaluation sites). Based on this, the potential mechanisms that were 'fired' in specific contexts to cause this outcome were identified using both qualitative and quantitative data sources, and also analysis findings from the other components of the evaluation. A set of new evidence-based CMOs was developed in the second phase of analysis. In the final phase, the CMOs that were supported by most evidence were selected and compared with the initial CMOs. Using an iterative process with several rounds of repeated refinements, a final set of CMOs was developed.

3.11 Ethics

Participation in this pilot and evaluation study was voluntary. All cadres in the study posyandus were approached separately to seek their informed consent to participate. All key informants participating in the evaluation were informed about the aims of the study and were given an information sheet with details of the study. All cadres agreed to participate and provided informed consent prior to the start of data collection. Mothers were given verbal explanations about the aims of the evaluation study, were informed about voluntary participation and were assured of confidentiality before giving informed verbal consent.

The Health Research Ethics Committee, National Institute of Health Research and Development and IDS ethics and research committee granted approval for the study. Thereafter, official permission to conduct the evaluation study in the selected sites was

granted by the Ministry of Internal Affairs and authorities in North and East Jakarta and Sikka.

All data sets from the growth monitoring activities were fully anonymous and can thus not be linked back to the individual child. All identifying information (names, locations, person-identifiable information, etc.) in the qualitative data were removed from quotes to ensure anonymity and pseudonyms were used. All data were stored on a secure server and access to the data was password protected and accessible by authorised researchers for the purposes of description and analysis.

3.12 Implementation challenges and limitations of the findings

3.12.1 Challenges related to the parallel data collection using paper and mobile phone

Due to statutory reporting obligations of the posyandus, it was impossible to suspend paper-based data collection in the evaluation sites. Consequently, the evaluation team decided to introduce the mobile phone-based nutrition monitoring in parallel to the paper-based system. This meant that nutrition data on each child were collected simultaneously using both systems. To allow for parallel data collection, posyandu procedures had to be changed and any interaction between the newly introduced cadre 3a (with mobile phone) and cadre 3 had to be minimised (e.g. by the location of the desks and asking the cadres to only focus on their specific tasks for the duration of the pilot). This was important to ensure that the impact of the mobile phone could be assessed rather than a combination of mobile phone and paper-based systems. Cadres in all 14 evaluation sites were informed about these necessary changes; they accepted them and adapted well to them. To allow the cadres time to get used to the parallel data collection systems and the presence of an observer, the initial three months of data collection was treated as a formative and ‘adaptive period’ and excluded from analysis. Also excluded was growth monitoring data on which cadres 3 and 3a interacted (as documented in the observation protocol) (see below for further details of excluded data).

Parallel data collection using both the paper-based and mobile phone-based system was perceived as a burden by one of the posyandus in East Jakarta as it created additional work and stress for the already overstretched cadres. It also posed a logistical challenge in four posyandus in Sikka as those posyandus were often operated by four or fewer cadres, making it difficult to change the procedures as required for the evaluation. While these posyandu sites did not use the mobile phone in every monthly posyandu session, they nevertheless continued use for the 12 months of the pilot and did not drop out.

3.12.2 Challenges related to the matching of paper-based and electronic records

To assess impact of the mobile phone, the growth monitoring records from the mobile phone-based and the paper-based systems had to be matched and compared at child- and posyandu-level. The records could not be matched completely, because paper records were missing (n=150) or records were only available on paper (n=180) (Table 3.3).

Table 3.3 Matching of child records collected with the mobile phone-based and the paper-based system

	Month 4	Month 7	Month 11	Total
Matched electronic and paper-based records for analysis (n)	386	323	332	1,041
Mobile phone records not available on paper (n)	57	29	64	150
Paper records not available in mobile phone (n)	73	38	69	180

The qualitative focus groups with the cadres and the observation protocol provided explanations for the incomplete matching. Data entry into the mobile phone was frequently discontinued for short periods of time during the posyandu and children who were measured during these periods were often only recorded on paper and not entered into the phone. Reasons for discontinuation included the following: cadre 3a had to help other cadres during peak attendance periods; technical issues with the phone ('phone got stuck', 'application needed to be refreshed', phone switched off, phone ran out of electricity and needed to be recharged); fluctuations in the data connectivity; and cadre 3a briefly left her position to do other activity (e.g. breastfeed, fix equipment, assist with immunisation, vitamin A campaign, Additional Meals Package provision, registration of children for early childhood development programmes). Explanations for the missing paper records included loss of paper slips during the posyandu (e.g. mother took slip by mistake) or illegibility. Given that the reasons for incomplete matching seem to be random and the analysis uses individual-level growth monitoring data (per child/month/posyandu), the validity of the results will not be affected by incomplete matching.

3.12.3 Data loss due to technical problems with server

Due to technical problems with the server, all mobile phone-based growth monitoring data for posyandu 01 in Sikka got lost. Consequently, this posyandu site had to be excluded from the evaluation of the impact on timeliness and data accuracy. Posyandu 01 was, however, included in the feedback analysis that was based on observer protocols.

3.12.4 Limited generalisability of findings

The number of sites was small, purposefully selected and cannot provide a representative sample of posyandus in Indonesia. A further caveat is that the evaluation focused only on sites with access to electricity and sites that received support from World Vision for the operation of the posyandu (e.g. through training of cadres). Consequently, the mobile phone application may fail to generate such impacts in less well-connected and well-supported posyandus. However, the mobile phone application aims to strengthen the existing posyandu system and provide support to cadres in areas with limited or no supervision. Consequently, the application's impact may be even greater in posyandus that receive low levels of support and supervision.

The selected sites are located in three macro areas of Indonesia and provide insight into the use of the mobile phone application in both urban and rural posyandus. Furthermore, the number of children eligible to use the selected posyandus and the profile of malnutrition (i.e. prevalence of underweight and overweight) varied among the sites and therefore allowed insights into the operation of the mobile phone application in different settings. An in-depth understanding of the context of each posyandu is important to understand and explain the impact of the mobile phone technology within the different settings (e.g. which factors may facilitate/promote or hinder uptake of the mobile phone solution). An assessment of the interaction between the contextual factors and the mobile phone and the consequences of this interaction is also important when considering applying lessons learned from this evaluation to other programmes in Indonesia and elsewhere.

4 Findings

This section presents the main findings from the impact evaluation on the use of the mobile phone application on accuracy, timeliness and responsiveness to growth monitoring. It is guided by the main evaluation questions. The section starts with a brief summary of the analysis findings of the contextual conditions within which the mobile phone application was embedded. A more detailed context analysis can be found in the formative phase report (Barnett *et al.* 2016). It then presents the findings on the impact of the mobile phone application on accuracy of growth monitoring status classification and timeliness. This is followed by the findings on the effect of the mobile on responsiveness as assessed by the propensity of the cadres to provide feedback and arrange home visits/referrals. The section concludes by presenting unintended and unexpected consequences and general lessons learned.

4.1 Contextual conditions within which the mobile phone application was embedded

4.1.1 Features of the posyandus

The 14 selected posyandus varied with regards to the number of cadres present during each session (ranging from 4–5 cadres in Sikka and 5–8 cadres in Jakarta), the number of children eligible to use the services (ranging from 15 in Sikka to up to 180 in East Jakarta) and the percentage of children (on average) identified as underweight each month (ranging from 0 per cent to 26.6 per cent of eligible children) and as overweight (ranging from 1.5 per cent to 3.5 per cent) (Table 4.1).

Table 4.1 Number and characteristics of posyandus, by rural and urban study sites

Study location	Study posyandu	No. of cadres[a]	No. of eligible children	Percent of underweight/month (%)		Percent of overweight/ month[d] (%)
				Dry season[b]	Wet season[c]	
Sikka_village 1	Sikka_01	4	40	12.5	7.5	0
	Sikka_02	5	66	3.0	4.5	0
Sikka_village 2	Sikka_03	4	47	10.6	4.2	0
	Sikka_04	5	15	13.3	26.6	0
Sikka_village 3	Sikka_05	5	40	12.5	7.5	0
	Sikka_06	5	41	4.9	7.3	0
	Sikka_07	4	15	0	0	0
Sikka_village 4	Sikka_08	5	28	7.1	10.7	0
	Sikka_09	4	23	13.0	8.7	0
	Sikka_10	5	43	6.9	4.6	0
East Jakarta	E Jakarta_11	8	180	2.2	2.8	1.5
	E Jakarta_12	8	154	5.2	5.2	1.9
North Jakarta	N Jakarta_13	6	114	5.3	3.5	2.6
	N Jakarta_14	5	112	5.4	6.3	3.5
Total	14	68	918	5.8	5.3	1.3

Notes: [a] Number of cadres who usually conduct the monthly posyandu; [b] dry seasons last from March to November ; [c] wet season lasts from November to April; [d] no difference in the prevalence of overweight between wet and dry season was found.

In the FGDs with the cadres, it emerged that cadres in East and North Jakarta (to a lesser extent) frequently felt 'overstretched' by the heavy workload caused by the large number of children who attended the growth monitoring sessions, especially during peak times. For example, one of the cadres in East Jakarta explained:

> *At our place, they [mothers with children] come as a group, the registration often gets overwhelmed, so becomes unmanageable.*
> (Cadre, FGD in month six, East Jakarta)

Based on the context protocols, mobile phone network coverage was available and stable in all study posyandus and at all times. However, there were some problems with speed and stability of the data connection (especially in Sikka). Data connection was needed to synchronise data at the beginning of the growth monitoring and to send child records to the cloud database after collection.

Access to electricity to charge the mobile phone was available and the logistics of regularly charging the phone were only mentioned as an occasional problem by cadres in one of the sites in East Jakarta. Safety concerns (e.g. theft of mobile phone) were not identified as a problem by the cadres in any of the sites.

To sum up, there were some contextual differences between the sites related to the operation (i.e. number of cadres present was lower in Sikka, stability of data connection) and workloads (i.e. high attendance of eligible children at peak times in East and North Jakarta) that could affect the uptake and successful implementation of the mobile phone application during growth monitoring.

4.1.2 Characteristics of the cadres

Cadres in Sikka were significantly ($P<0.005$, for each) younger, less educated and less likely to know how to operate a smartphone compared to cadres in East and North Jakarta. Cadres in Sikka also seemed to have worked slightly longer (no significant difference) in a posyandu compared to cadres in East and North Jakarta.

Cadres in East Jakarta were older and slightly less educated than cadres in North Jakarta. There were no significant differences between the cadres with regards to ownership of and familiarity with a mobile phone, and ability to send and receive text messages.

Table 4.2 Characteristics of cadres and familiarity with mobile phones

Cadre characteristics	Sikka N=42	East Jakarta N=16	North Jakarta N=11	p-value
Age (in years)				
20–34	14	0	1	
35–49	21	9	8	
>50	7	7	2	0.002
Age in years (mean, SD)	39.9 (9.8)	50.1 (7.6)	45.5 (7.9)	<0.005
Average length of work in posyandu (mean, SD)	12.7 (8.5)	11.1 (12.8)	10.9 (9.0)	0.8
Education in years (mean, SD)	8.7 (2.2)	11.2 (1.6)	11.6 (1.2)	<0.005
Ownership of any[a] mobile phone				
No	6	1	0	
Yes	36	15	11	0.3
Sends text messages				
Never	5	1	0	
Every week	13	1	1	
Every day	24	14	9	0.1
Operates smartphone				
No	38	7	7	
Yes	4	16	11	<0.005

Abbreviations: SD, standard deviation. [a] includes simple analogue mobile phones and smartphones.

According to the qualitative data, age emerged as an influence on the motivation and perceived ability to use the mobile phone for growth monitoring, especially in the two sites in East Jakarta.

> *I rarely use a mobile phone. My eyesight started to weaken with age so I have to use glasses. Sometimes I like pressed the wrong button. I often fear when asked to hold the phone.*
> (Cadre, 55 years old, FGD in month 12, East Jakarta)

> *I am not fast enough because I'm old rarely dealing with these things, younger people have mobile, I don't understand so I'm not fast enough. They are too small and I'm not familiar with cell phone just taking and making phone calls.*
> (Cadre, 48 years old, FGD in month 12, East Jakarta)

> *Because I am old, it is difficult for my eyes if I use it, need to slide like that, and could not see.*
> (Cadre, 52 years old, FGD in month 3, North Jakarta)

Several cadres in Sikka were worried that they are 'too uneducated' to understand how to operate the mobile phone:

> *I don't know how to use the mobile phone, because of my education, only elementary school. I don't know how to text or to call someone. Therefore I am giving the mobile phone to the elder or other.*
> (Cadre, FGD in month 3, Sikka)

I never had the chance go to school more than elementary. Also don't know how to text, that is why I am giving the chance to the elder.
(Cadre, FGD in month 6, Sikka)

To sum up, there were some differences between cadres in terms of their age and education profile and familiarity with smartphones that may influence successful uptake and operation of the mobile phone in the posyandus. Cadres in Sikka were, on average, less educated and less familiar with smartphones, whereas cadres in East Jakarta were older.

4.2 Impact of the mobile phone application on accuracy of growth monitoring

Table 4.3 presents the findings of the comparison of growth monitoring status classifications based on paper and mobile phone records by posyandu. A total of 747 paper- and mobile phone-based child records were collected from 13 posyandu sites in months four, seven and eleven of the pilot. Without the mobile phone, cadres misclassified the growth monitoring status of around one in three children (33.9 per cent). Misclassification rates for cadres without a phone ranged from 16 per cent (East Jakarta 12) to 63 per cent (Sikka 06). There were no misclassifications of growth monitoring status found in one posyandu site (although only five matched records were available from this site (Sikka 07), limiting the value of the comparison). The mobile phone improved accuracy of growth monitoring status classifications, with improvements ranging from 19 per cent to 171 per cent compared to accuracy of classification without the phone.

Table 4.3 Descriptive comparison of growth monitoring status classification based on paper and mobile phone, by study sites (based on data from three posyandu sessions per site)

Posyandu sites[a]	No. of children	Does growth monitoring status classification match?		Misclassification rate without phone (%)	Improvement in classification with phone (%)
		No (n)	Yes (n)		
Sikka 02	71	38	33	53.52	115.17
Sikka 03	51	29	22	56.86	131.81
Sikka 04	21	12	9	57.14	133.32
Sikka 05	44	16	28	36.36	57.13
Sikka 06	19	12	7	63.16	171.43
Sikka 07	5	0	5	0	0
Sikka 08	28	14	14	50	100
Sikka 09	19	9	10	47.37	90
Sikka 10	16	5	11	31.25	45.45
E Jakarta 11	121	36	85	29.75	42.35
E Jakarta 12	238	38	200	15.97	19
N Jakarta 13	52	15	37	28.85	40.55
N Jakarta 14	62	29	33	46.77	87.88
Total	747	253	494	33.87	51.21

Note: [a] Data from posyandu Sikka 01 were lost due to technical problems and were not included in the accuracy analysis.

To gain a better understanding of the nature and potential impacts of the misclassifications that occurred without the phone, the numbers of children classified in each growth monitoring status category (normal, mildly, moderately, severely underweight and overweight) based on paper and mobile phone were compared (Table 4.4). The analysis showed that classification by paper misclassified the majority (98 per cent) of mildly underweight children as normal weight and also incorrectly categorised 18 per cent of the moderately underweight children as normal weight. This means that these children would not be detected as at risk for undernutrition with the paper-based system and would not receive cadres' support to prevent a further decline of their nutritional status. Further, based on the paper system, 77 per cent of moderately underweight children were misclassified as mildly underweight. Accurate classification is vital to ensure early detection of even mild forms of underweight as this enables timely action and prevention of more severe forms of underweight at a later stage. There was no misclassification of overweight.

Table 4.4 Frequency analysis by growth monitoring status classification based on paper and mobile phone

		Paper-based growth monitoring status classification					
Mobile phone-based growth monitoring status classification	**Nutritional status**	**Normal**	**Mild under weight**	**Moderate under weight**	**Severe under weight**	**Over weight**	**Total**
	Normal	458	4	0	0	0	462
	Mild underweight	189	2	0	0	0	191
	Moderate underweight	10	44	0	3	0	57
	Severe underweight	0	1	1	2	0	4
	Overweight	0	0	1	0	32	33
	Total	657	51	2	5	32	747

Aggregated analysis (Table 4.5) found that the mobile phone significantly improved accuracy of growth monitoring status classification by 80 per cent on average compared to its paper-based counterpart (95% CI (75.9–83.1), p=0.005). Average improvements in accuracy varied by context and were especially great in the posyandus in Sikka, with an average improvement rate of 94 per cent. Among the urban sites, improvements in accuracy of growth monitoring status classifications were considerably greater in North Jakarta than in East Jakarta (64 per cent vs 31 per cent).

Table 4.5 Mean improvement rates in accuracy of growth monitoring status classification with mobile phone compared to paper-based classification, stratified by rural and urban posyandus

	No. of children	Median improvement rate in accuracy with mobile phone (%)	Mean improvement rate in accuracy with mobile phone (%)	SD	95% CI	p-value
Sikka (02–10)	274	100	93.81	52.5	87.6–100.1	0.005
East Jakarta (11–12)	359	30.68	30.68	16.5	28.9–32.4	0.005
North Jakarta (13–14)	114	64.2	64.21	33.4	58.0–70.4	0.005
Total	**747**	**87.88**	**79.54**	**50.1**	**75.9–83.1**	**0.005**

Age and education level of the cadres was associated with the impact of the mobile phone application on accuracy. Lower education and younger age of cadres was significantly associated with higher misclassifications rates of growth monitoring status and greater improvement in accuracy with the mobile phone. Consequently, the impact of the mobile phone on accuracy was most pronounced in the study posyandus in Sikka, which had younger and less-educated cadres (p=0.005 for education; p=0.001 for age). In the FGDs, cadres from the different Sikka sites corroborated these findings and explained how they often struggled with the plotting and how the mobile phone made the process easier for them. For example, a cadre from Sikka 04 described:

> *Okay, […] when we have to count this and count that [for the manual plotting], we only graduate from elementary school... So yes, with this mobile phone it made our work easier because we can simply follow the direction that we know the result from it.*
> (Cadre, FGD in month six, Sikka)

In East Jakarta, posyandu 11 benefited considerably more from the improvement in accuracy than posyandu 12 (42 per cent vs 19 per cent). As in Sikka, cadres in posyandu 11 were significantly less educated than cadres in posyandu 12 ($p < 0.005$). The qualitative data additionally suggested that some of the cadres in East Jakarta 11 were unsure of and/or inexperienced in manually plotting and did not feel sufficiently supported and trained by the posyandu lead to do it.

> *Interviewer: Which one is easier to do, mobile or paper growth chart?*
> *Cadre 1: Depending on the person. For smart people, it is easy to understand the paper. Since I entered the posyandu, I do not understand anything about the paper growth chart. Several times posyandu chairwoman asked me to fill growth chart. I am a newbie, do not even know what growth chart is. She did not teach us. She just said, as a cadre should be able to do all things […]*
> *Cadre 2: Knowledge [of how to plot on the paper-based growth chart] must be applied every day, if it is not used, it will be forgotten. I have never given credence to fill growth chart. Until one day I was asked to do the plotting. I was confused how to make it. I called Mrs P [other cadre], and then she explained the steps.*
> *Cadre 1: Since using mobile phone, we can directly read the nutritional status. If the child is in malnutrition, we can immediately provide counselling.*
> (Cadres, FGD in month 12, East Jakarta 11)

This suggests that the mobile phone might be especially effective for improving accuracy of growth monitoring in contexts with young and/or low-educated cadres and limited training/supervision of cadres.

While the mobile phone application improves the accuracy of the calculation of growth monitoring status, it does not improve the accuracy of the anthropometric measurements taken by the cadres. To ensure accurate anthropometric measurement, adequate training of the cadre is essential.

4.3 Impact of the mobile phone application on timeliness of growth monitoring

Timeliness is a key measure of any nutrition monitoring and surveillance system. Timely access of sub-district health officers to community-based nutrition data is important to initiate rapid responses to cases of child undernutrition and to inform effective action.

Table 4.6 presents the median time lags between data collection in the posyandu and data access at sub-district level. The findings are the result of the comparison of mobile phone and paper-based time records of 52 posyandu sessions collected in months four, seven and eleven of the pilot from 13 sites. The mobile phone increased the timeliness of the growth monitoring in all posyandus, with median time lag differences between mobile and paper-based systems ranging from 1.5 hours to more than 241 hours.

Table 4.6 Median time lags between data collection in the posyandu and data access in sub-district health office

	Median lag time mobile (hrs)	Median lag time paper (hrs)	Median time lag difference (hrs)
Sikka 02	1.5	13.3	10.5
Sikka 03	1.9	13.3	10.7
Sikka 04	1.3	12.7	1.5
Sikka 05	1	15.2	14.2
Sikka 06	0	2.1	2.1
Sikka 07	0.2	2	1.8
Sikka 08	0.8	3	1.7
Sikka 09	5.65	13	12.3
Sikka 10	0.85	3	2.2
E Jakarta 11	0	230.4	230.4
E Jakarta 12	0	289.2	241.4
N Jakarta 13	0	86	86
N Jakarta 14	116.1	139.2	71.6

Table 4.7 presents the stratified analysis of the time lag differences between the two systems. On average, data submission using the mobile phone was significantly timelier, with mobile phone-based data being on average 52 hours or 2.1 days faster than paper-based reporting (95% CI (24.2–79.4 hours), p=0.005). Improvements in timeliness were especially pronounced in the Jakarta sites, with electronic data being available to sub-district-level

health officers approximately six days earlier than data based on the paper system (95% CI (81.4–222.6 hours), p=0.005).[13]

Table 4.7 Comparison of mean time lags between data collection and data access based on paper and mobile phone, stratified by rural and urban posyandus

	No. of reports submitted	Mean lag time mobile (hrs)[a]	Mean lag time paper (hrs)[b]	Mean lag time difference (hrs)[c]	SD lag time difference (hrs)[c]	95% CI (difference)	p-value
Sikka	36	3.2	10.4	7.2	13.4	0.06–14.34	NA
Jakarta	16	35.2	187.2	152.0	132.5	81.41–222.57	0.005
Overall	**52**	**13.0**	**64.8**	**51.8**	**99.2**	**24.18–79.42**	**0.005**

Notes: [a] difference between end time of posyandu and submission of mobile phone-based data to the electronic data base; [b] difference between end time of posyandu and submission of paper-based data to the sub-district health office; [c] difference between paper-based and mobile phone-based data submission time.

Timely access to growth monitoring data is important to enable timely response to malnutrition. Submission to sub-district-level only constitutes the first step in the reporting of posyandu data and each further data transmission (to district and central levels) may cause additional cumulative time delays that can be reduced with the mobile phone application.

Mobile phone technology improved the timeliness of growth monitoring; however, more timely data does not automatically translate into more timely response (Ramalingam 2016). Whether mobile phone-based (real-time or nearly real-time) data trigger faster and better decision-making for nutrition depends on multiple contextual factors. These include: perceptions of the value of nutrition data collected during the posyandu; the health system's readiness, flexibility and capacity to respond to real-time data on nutrition; and the existing culture of decision-making and whether empirical data are considered in the current process (Barnett and Gallegos 2013; Ramalingam 2016; Lucas, Greeley and Roelen 2013).[14]

4.3.1 Delays in data submission by mobile phone

Data collected with the mobile phone application can be available in real time (connectivity permitting). In practice, real-time data access was rare (see Table 4.6, median lag time for the mobile phone > 0 for most posyandus). According to the qualitative data there were several reasons for the delay.

In the Jakarta sites in particular, cadres usually entered some of the growth monitoring data into the mobile phone after the posyandu session finished, as data entry was difficult during the peak times of the posyandu. Registration of new children could be particularly time-consuming with the mobile phone and was frequently done after the posyandu, as highlighted in the following quote from East Jakarta.

> *Cadre 1: No piling up [of child records to be entered into the mobile phone] in my posyandu, 5 would be most, it used to be plenty due to too many apps, but not anymore, 2 would be the most, unless if there is registration, I would leave it.*
> *Cadre 2: Yes, if it is new, after everything is finished, the data can be entered later if it is taking too long.*
> (Cadres, FGD in month 12 , East Jakarta)

[13] Due to the small sample size (n=16), stratified analysis for the Jakarta sites was not done.
[14] Barnett *et al.* conducted a stakeholder interview study in Indonesia in December 2015/January 2016 to explore local and national stakeholders' perceptions, views and opinions on the feasibility, barriers to and facilitators of the use of real-time growth monitoring data to inform decision-making for nutrition. The findings of this study will be published shortly.

Other small delays in the data submission were caused by slow or instable data connection for up-loading of the data to the server and continued active growth monitoring of children who were not presented at the posyandu for one or two days after the posyandu (*'if they don't show up, sometimes we patrol till afternoon'*). Several cadres also described how they checked the growth monitoring data that were entered into the phone after the posyandu and before submission to ensure correct and complete data entry.

4.3.2 Accelerated data collection during the posyandu

According to qualitative interviews, the mobile phone application did not just accelerate transfer and submission of data to the sub-district, but also the actual data collection procedure during the posyandu. Here, the mobile application enabled quicker calculation and classification of growth monitoring status and also accelerated retrieval of the child's details (compared to searching the manual registration book). For instance, a cadre from East Jakarta commented:

> *I think the mobile lessened time because it's faster, usually the child goes to registration first, then measurement, but now it's simpler, cadre only needs to seek the child's name [in mobile phone], then click – there it is [the child's registration details].*
> (Cadre, FGD in month 6, East Jakarta)

4.3.3 Overall length of posyandu session increased

While the mobile phone application improved timeliness of data submission and collection, the qualitative interviews suggest that the overall length of the posyandu session increased (in all sites). As two cadres from Sikka 07 explained:

> *Cadre 1: And then, for the presence status, before there is mobile phone, they usually just arrived at 9.00, and at 9.30 they came to weigh their children... Now, when there is mobile phone, they often come at 8.00... They are here.... and they are also fast.*
> *Cadre 2: It might take long time and queueing, so they come earlier in the morning.*
> (Cadre, FGD in month 6, Sikka)

One reason for this increase was that cadres with the mobile phone were more likely to provide feedback on the child's growth monitoring status to the mothers and often also provided immediate nutrition counselling if necessary (see also 4.4.1). Mothers in all Sikka and North Jakarta sites also actively requested feedback based on the mobile phone and were happy to wait for their turn. For example:

> *They do not want to go home if they have not met mobile phone. They prefer to queue up and be more patient.*
> (Cadre, FGD in month 12, North Jakarta)

> *… they want to queue to see together in the mobile phone… They are also curious with the others… Last month my child got the thumbs like this… Who knows this month will get thumbs like this… So they are curious… Want to know as well…*
> (Cadre, FGD in month 12, Sikka)

4.4 Impact of the mobile phone application on responsiveness to the data

An important element of effective community-based growth monitoring is the provision of feedback to the mothers (Mangasaryan *et al.* 2011). Raising the mother's awareness of the child's growth monitoring status helps to reassure and empower them to track the child's nutritional health and take adequate actions to improve in case growth faltering is detected.

4.4.1 Feedback-giving during the posyandu

Figure 4.1 and Table 4.8 present the descriptive findings on cadres' feedback-giving during the posyandu, and which channels cadres used. The findings are based on 2,276 observation records collected in six growth monitoring sessions per posyandu in all 14 sites. In Sikka and North Jakarta, the majority of mothers (> 85 per cent) received feedback on the nutritional status of their child from the cadre with the mobile phone. Only a small proportion of mothers did not receive any feedback – 2.7 per cent in Sikka and 3.3 per cent in North Jakarta. By contrast, only 22.6 per cent of mothers in East Jakarta received feedback; 16 per cent of those were from the cadre with the mobile phone and 6.6 per cent from the cadre without a phone.

Figure 4.1 Feedback-giving and channel used during the posyandus, by evaluation sites and based on aggregated data from six posyandus per site (n=2,276)

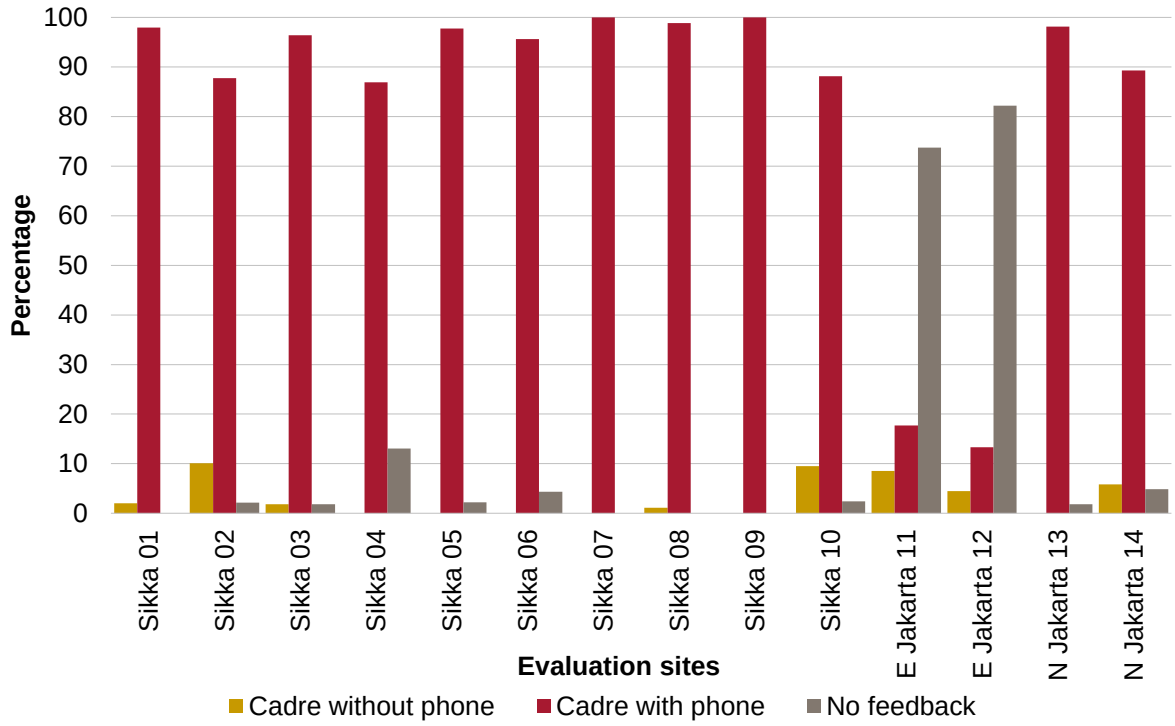


Table 4.8 Summary of absolute feedback provision during posyandu, by site and based on aggregated data from six posyandus per site*

	No. of children measured	Feedback provided by					
		Cadre with phone		Cadre without phone		No feedback	
	n	n	%	n	%	n	%
Sikka	1,135	1,062	93.57	42	3.7	31	2.73
East Jakarta	930	145	15.59	61	6.56	724	77.85
North Jakarta	211	198	93.84	6	2.84	7	3.32
Total	2,276	1,405	61.73	109	4.79	762	33.48

Note: *Excludes observations where both cadres provided feedback and observations where cadres 3 and 3a communicated about the child's nutritional status

Table 4.9 presents the relative percentage of mothers who received feedback from cadres with the mobile phone, stratified by urban and rural sites. Of the mothers who received feedback, a significantly higher proportion (93 per cent) received it from cadres with mobile phones (mean feedback rate with phone 93.7 per cent (95% CI (93.3–94.3)). The relative percentage of mothers who received feedback from cadres with mobile phones was 96 per cent in Sikka and 97 per cent in North Jakarta, but only 70 per cent in East Jakarta.

Table 4.9 Relative feedback provision with mobile phone during the posyandu, stratified by urban and rural sites

	No. of children who received feedback	Feedback given by cadre (n)		Relative percentage of feedback by mobile phone (%)	Mean feedback rate with mobile phone	SD	95% CI	p-value
		With phone	Without phone					
Sikka	1,104	1,062	42	96.2	97.5	0.04	97.2–98.3	0.005
East Jakarta	206	145	61	70.4	71.2	0.05	71.0–72.4	0.005
North Jakarta	204	198	6	97.1	96.9	0.04	96.6–98.3	0.005
Total	1,514	1,405	109	92.8	93.7	0.10	93.3–94.3	0.005

The findings on cadres' feedback-giving with the mobile phone were mostly collaborated by the findings from the exit interviews (n=519) with mothers (Table 4.10). In both Sikka and North Jakarta, the majority of mothers (97 per cent and 81 per cent respectively) reported receiving feedback on the nutritional status of their child from the cadre with the phone, whereas this figure was only 35 per cent for mothers in East Jakarta. In East Jakarta, most mothers either received feedback from the cadre without the phone (36 per cent) or did not receive any feedback (29 per cent).

Table 4.10 Feedback provision by cadres and channel used as reported by caregivers, stratified by rural and urban sites

Person who provided feedback	Sikka		East Jakarta		North Jakarta		Total	
	n	%	n	%	n	%	n	%
Mothers interviewed (N)	**168**	**168**	**243**	**243**	**108**	**108**	**519**	**519**
Nobody	3	1.8	71	29.2	10	9.3	84	16.2
Cadre with phone	163	97	85	35	87	80.6	335	64.5
Cadre without phone	1	0.6	87	35.8	9	8.3	97	18.7
Other	1	0.6	0	0	2	1.9	3	0.6

4.4.2 Reasons for and contexts within which the mobile phone application increases feedback-giving during growth monitoring

A realist approach was chosen to explore how and in which conditions the mobile phone application may increase feedback-giving during the posyandu. The findings are presented as conjunctured context-mechanism-outcome (CMO) configurations in Table 4.11. The eight CMOs presented provide the most robust evidence (based on available qualitative and quantitative evidence) for why the mobile phone application increased responsiveness in the different contexts.

Table 4.11 Context-mechanism-outcome configurations that explain why and within which contexts the mobile phone application increases cadres' propensity to provide feedback

	Context	Mechanism	Outcome
CMO 1	Cadres are unsure of the correct plotting procedures, how to read and how to interpret the growth charts correctly (due to limited training/supervision, general low formal education, inexperience). Cadre is not able to provide feedback	Mobile phone calculates growth monitoring status and velocity automatically and cadre only has to read out/show results to mother without performing any calculations. Cadres can provide feedback	Cadres are more likely to provide feedback (than they were without a phone)
CMO 2	High attendance rates of children during growth monitoring causes backlogs of child records that need to be plotted. Due to time pressure and requests from impatiently waiting mothers, cadres just complete the growth charts and hand it to mothers without feedback	Mobile phone accelerates plotting and also feedback provision as cadres do not have to talk much and can just show the mobile phone screen with the results of the plotting to the mothers. Cadres feel less stressed	Cadres are more likely to provide feedback (than they were without a phone)
CMO 3	Younger and/or less-educated cadres doubt their plotting and interpretation skills of the growth monitoring status and therefore do not give feedback	Mobile phone calculates and classifies growth monitoring status and velocity immediately and accurately. Cadres trust automated calculations	Cadres are more likely to provide feedback (than they were without a phone)

(Cont'd.)

Table 4.11 (Cont'd.)

CMO 4	Growth monitoring in posyandu is understaffed with only 3–4 cadres present. To reduce the workload for the cadres, no feedback is provided	Mobile phone facilitates work for cadres by accelerating data entry and plotting. Cadres feel less stressed	Cadres are more likely to provide feedback (than they were without a phone)
CMO 5	Cadres find it difficult to communicate negative feedback to mothers as they are afraid to offend ('difficult to find right words', 'words come out wrong and offensive') (especially highlighted in North Jakarta)	Mobile phone provides visual feedback that cadres can directly show to the mother. No or very limited talking is required from cadre	Cadres are more likely to provide feedback (than they were without a phone)
CMO 6	Mothers do not understand the paper-based growth chart and do not value feedback the cadre provides based on the plotting of the growth chart. Mothers leave straight after the child's anthropometric measurements are taken	Mobile phone provides visual, easily accessible information on the child's growth monitoring status. Mothers understand this feedback and are willing to wait at the posyandu to receive feedback. They also actively request to see the mobile phone screen with the feedback (thumbs, colour ribbon)	Cadres are more likely to provide feedback (than they were without a phone)
CMO 7	Mothers do not trust the feedback based on manual plotting and frequently challenge cadre on accuracy of calculation. To avoid conflict, cadre prefers not to provide feedback	Mothers trust calculations based on mobile phone and are more likely to accept feedback based on mobile phone	Cadres are more likely to provide feedback (than they were without a phone)
CMO 8	Mothers perceive negative feedback as shaming and react aggressively or defensively. To avoid conflict, cadre does not provide feedback	Cadres believe that nutritional status calculations based on mobile phone are more objective and less judgemental	Cadres are more likely to provide feedback (than they were without a phone)

The mobile phone considerably increased the provision of feedback by cadres in Sikka and North Jakarta (compared to cadres with no phone). In East Jakarta, the proportion of mothers who received feedback from cadres with a phone was higher than the proportion who received feedback from cadres without a phone (18 per cent vs 9 per cent in posyandu East Jakarta 11; 13 per cent vs 4 per cent in posyandu East Jakarta 12). Nevertheless, the majority of mothers in East Jakarta still did not receive any feedback (74 per cent in East Jakarta 11; 82 per cent in East Jakarta 12). The FGDs with cadres in East Jakarta suggest several reasons why the mobile phone application was less effective in increasing the propensity for feedback there.

First, both posyandus in East Jakarta provide growth monitoring to considerably more children than the sites in Sikka and North Jakarta (see Table 4.8). Cadres were frequently 'overwhelmed' by mothers with children during the growth monitoring. One cadre from East Jakarta described the challenge as follows:

> *We start to find difficulties when many mothers with their children come together at once. We could not handle all children here.*
> (Cadre, FGD in month 6, East Jakarta)

The provision of individual feedback to each mother was often perceived as impossible under these conditions, especially as mothers were usually in a rush and left the posyandu as soon as the weighing was completed, as highlighted in the following quotes:

> *[...] from arrival [in posyandu] until departure, maximum half an hour, if more than half an hour, mothers will be anxious: 'oh, haven't picked up my other child… oh… I left my washed clothes' […] mother is impatient, so when we want to ask, s/he is gone, so when they come, then child is weighed and then after that go home.*
> (Cadre, FGD in month 6, East Jakarta)

> *(mothers) come after that weighed and then measured and then come to my table for recording and feedback this is on table 3, but often they directly go to supplementary feeding station (PMT/* Pemberian Makanan Tambahan*) and s/he will go straight home.*
> (Cadre, FGD in month 3, East Jakarta)

> *We have to do everything faster. So that the mothers should not have to wait longer.*
> (Cadre, FGD in month 12, East Jakarta)

Second, several cadres from East Jakarta 11 were not convinced about the usefulness of the classification of growth monitoring status and the plotting in a growth chart, and thus often did not provide feedback. One cadre summarised this as follows:

> *I don't want to underestimate anyone. But I try to fill the growth chart. Then I thought further. Why would I make something that is not in use? It has never been used. We can't even see if weight goes up or down.*
> (Cadre, FGD in month 12, East Jakarta)

Third, in both posyandus in East Jakarta, differences in the classification of growth monitoring status based on paper and mobile phone caused huge frustration and confusion among cadres and mothers alike. Cadres were concerned that the confusion would cause mothers to drop out of the posyandu completely. Consequently, they either did not provide any feedback or provided feedback based on the traditional paper-based calculation only.

> *The mothers said 'why on the paper green, but on the mobile phone yellow?' so I will say 'ok Bu [mother], I will put green then' well, rather than we misinformed and she does not want to come, because if she felt irritated then she would not come again… There are some cases like that, we say 'Bu, your child's weight had not increased for the last 3 months' and then the following did not show up… Don't want their child was told decline in weight… Just don't want.*
> (Cadre, FGD in month 3, East Jakarta)

4.4.3 Arrangements for nutrition counselling or referrals for underweight children

Figure 4.2 and Table 4.12 show the findings from the descriptive analysis of the observation records on arrangements for counselling/referrals for children identified as underweight during the posyandu. From the 2,276 children that were assessed, 262 were followed up with individual nutrition counselling session or referral for treatment. The trigger for home-based counselling was the detection of mild underweight or overweight and the trigger for referrals was severe underweight. In all 14 evaluation sites, cadres with the mobile phone organised the majority of counselling sessions or referrals.

Figure 4.2 Arrangements for counselling/referrals and channel used during the posyandus, by evaluation sites and based on aggregated data from six posyandus per site (n=2,276)

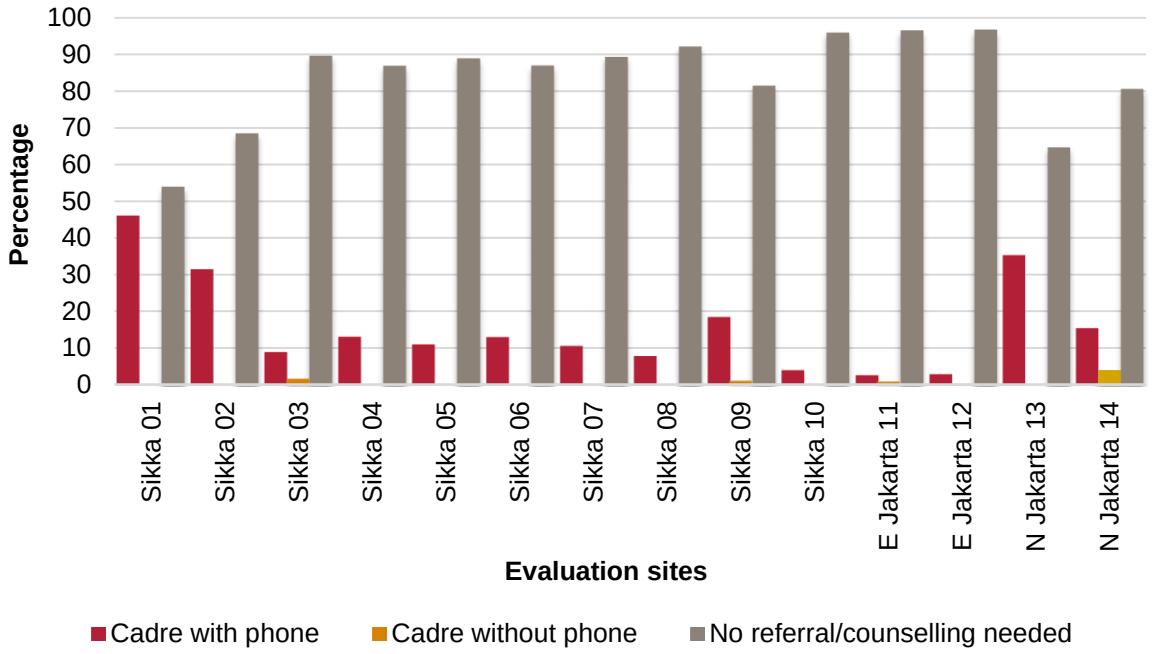


Table 4.12 Summary of arrangements for counselling/referrals during posyandu, by site and based on aggregated data from six posyandus per site

	No. of children	No. of children who were counselled/ referred	Cadre with phone		Cadre without phone		No referral/home visit needed	
	n	n	n	%	n	%	n	%
Sikka	1,135	185	182	16.0	3	0.3	950	83.7
East Jakarta	930	31	26	2.8	5	0.5	899	96.7
North Jakarta	211	46	43	20.3	3	1.5	165	78.2
Total	2,276	262	251	11.1	11	0.5	2,014	88.4

Table 4.13 presents the relative percentage of appointments for counselling/referrals organised by cadres with a mobile phone, stratified by urban and rural sites. Of the appointments/referrals that were set up, a significantly higher proportion (96 per cent) were organised by cadres with mobile phones (mean counselling/referral rate with phone 94.8 (95% CI (94.2–96.3)). The relative percentage of appointments/referrals organised by cadres with a mobile phone was slightly less in East Jakarta than North Jakarta and Sikka.

Table 4.13 Relative percentage of arrangements of counselling/referrals with mobile phone during the posyandu, stratified by urban and rural sites, from six posyandus per site

	No. of children referred/ counselled	Counselling/ referrals by cadre (n)		Relative percentage of counselling/ referral by mobile phone (%)	Mean counselling/ referral rate with mobile phone	SD	95% CI	p-value
		With phone	Without phone					
Sikka	185	182	3	98.3	98.9	0.05	97.1–98.3	0.005
East Jakarta	31	26	5	83.9	85.8	0.12	81.4–89.5	0.005
North Jakarta	46	43	3	93.5	90.0	0.14	86.5–94.4	0.005
Total	262	251	11	95.8	94.8	0.08	94.2–96.3	0.005

4.5 Unintended and unanticipated consequences of the mobile phone application on growth monitoring during the posyandu

4.5.1 Positive unintended and unanticipated impacts

Higher regard for posyandu and cadres

The introduction of the mobile phone for growth monitoring in the posyandu influenced how cadres perceived themselves (e.g. 'smarter', 'more modern', 'have more knowledge') and also how mothers and stakeholders at local and sub-district-level viewed the posyandu. In the FGDs (in all sites) cadres recalled how the posyandu with the mobile phone was described as 'more modern', 'more international', 'more elite', 'more sophisticated', 'smarter', 'more intelligent' and 'more advanced' by mothers, health workers and officials.

> *Cadre 1: I'm proud of myself [for using mobile phone]. Head of sub-district asked me some questions. He's interested. He said that now we are more advanced, more intelligent, and it should be continued.*
> *Cadre 2: Yesterday Ms K [from sub-district office] contacted me and asked me to go to the district office, to explain the use of this phone.*
> (Cadres, FGD in month 6, North Jakarta)

4.5.2 Negative unintended and unanticipated impacts

Change of dynamics and power relationships between cadres

In one evaluation site (East Jakarta 11) the introduction of the mobile phone caused tensions between the cadres. Some cadres actively supported the use of the phone, whereas the chairwoman was reluctant about its use. The underlying reason for her reluctance emerged from the FGDs, which found that the chairwoman liked to be in control of all posyandu activities at all times. The mobile phone posed a potential threat to her position of power, especially as she did not use the mobile phone herself.

Interviewer: Does the head use the mobile phone?
Cadre 1: No, but she likes to comment 'don't do the mobile phone first, do manual first.'
Cadre 2: But sometimes, when we're slow, she's also slow, so when she's not finished and we already finished, she will be angry and grumpy.
Cadre 3: Our chairwoman is a bit strange.
Cadre 1: Because she handled everything, she's at the big book registration, so she often mad when we're done and she hasn't.
(Cadres, FGD in month 3, East Jakarta)

According to the agreement [for pilot study], the credits will be provided by the chairwoman of the posyandu [and she receives the credit from World Vision]. But sometimes she scolds us if we run out credits. She is a little selfish. Not willing to listen and protecting others.
(Cadre, FGD in month 6, East Jakarta)

Throughout the pilot period, the tensions between the cadres who wanted to use the mobile phone and the chairwoman increased until the mobile phone was only employed occasionally for growth monitoring. By the end of the pilot, the tensions between cadres and others who were supportive of using mobile phones and those who were not supportive had further increased. The supporters wanted to continue using the application independently of what the chairwoman decided and were also willing to fund the credits by themselves.

No similar tensions were found between cadres in the other study sites. However, there were three instances when cadres who did not use the mobile phone application during growth monitoring felt envious of the ones who did.

Tensions with local health workers
For this pilot and evaluation study, cadres at the 14 sites were trained on how to operate the mobile phone application for posyandu activities. Local health workers and midwives were informed about the study (and also helped with some of the data collection); however, they were not included in the training and did not receive a mobile phone. In one of the sites in East Jakarta, local health workers felt offended not to have been included and tensions between the posyandu and the local health office developed.

Cadre 1: The first time, invited, only the cadres in posyandu. No part of the health centre or village. If you want to implement this, we must involve everyone.
Cadre 2: Hopefully we can do.
Cadre 1: If you already have the support of all parties, we can work more comfortably.
(Cadres, FGD in month 12, East Jakarta)

4.6 Other lessons learned

4.6.1 Need for ongoing technical support
Throughout this evaluation study, World Vision provided technical support to the posyandus. In the early months in particular, cadres required a lot of support. While cadres were more familiar with the application by the end of the pilot and were also able to help each other in case of problems, the availability of technical support was still perceived as important, and was mentioned in most of the FGDs conducted in month 12. For example,

A bit worried too, if there is no Ms D [World Vision support staff]. Because despite the advanced technology, we also sometimes still forget or have difficulty to apply.
(Cadre, FGD in month 12, North Jakarta)

4.6.2 Challenging logistics of organising regular mobile phone top-ups

To keep the mobile phone application in operation, it was important to top-up the mobile phone credits on a monthly basis (the costs for top-ups were covered by World Vision during the pilot). The logistics of organising regular top-ups were challenging for some study posyandus and were a frequent cause of concern for some cadres.

5 Conclusions

This impact evaluation used a multi-site case study approach to assess the impact of a mobile phone application on accuracy and timeliness of, and responsiveness to, community-based growth monitoring data in Indonesia.

Conclusion 1: The mobile application increased the accuracy of growth monitoring
The mobile phone application significantly improved the accuracy of growth monitoring status classifications. It especially increased the capture of mildly underweight children that were missed with the paper-based system. The effect of the mobile phone application was most pronounced in posyandus in Sikka, which had younger and/or less-educated cadres, and in one posyandu in East Jakarta, where cadres reported limited training and supervision for manual plotting. While the mobile phone application improves the accuracy of the calculation of growth monitoring status, it does not improve the accuracy of the anthropometric measurements taken by the cadres. To ensure accurate anthropometric measurement, adequate training of the cadre is essential.

Conclusion 2: The mobile phone application improved the timeliness of growth monitoring
The mobile phone application improved the timeliness of data submission from the posyandu to the sub-district-level significantly. Especially in the Jakarta sites, access to the data was faster (by approximately six days compared with the paper-based system). Delayed data entry, slow data connections, and entering data after the posyandu had ended caused small delays in the mobile phone-based growth monitoring. According to the qualitative data, the mobile phone accelerated the nutrition data collection by facilitating quicker retrieval of each child's details and classification of growth monitoring status. Nevertheless, the posyandu sessions had become longer since the introduction of the mobile phone, mainly because cadres were more likely to provide feedback and counselling to the mothers, and mothers also actively requested to receive feedback based on the phone results.

Conclusion 3: The mobile phone application increased cadres' responsiveness to the data during growth monitoring
Cadres who used the mobile phone for growth monitoring were more likely to provide feedback and arrange follow-up counselling sessions/referrals than cadres without a phone. Many context-specific reasons for the improvement in cadres' responsiveness were identified. For example, the mobile phone enabled cadres with low plotting skills and/or high workloads (due to high attendance rates or understaffing) to provide feedback based on immediate and automated growth monitoring status classification. As well as actively requesting feedback from the cadres based on the mobile phone application, mothers seemed to value it and understand it better. The impact of the mobile phone on the propensity of feedback-giving was considerably less in East Jakarta than in North Jakarta and Sikka.

The evaluation also identified some unintended positive impacts of the intervention (higher regard for the posyandu and cadres) and some negative impacts (tensions and changed power-dynamics within the posyandu, and tensions with local health workers).

The results of this impact evaluation must be treated with care, because the evaluation sites were purposefully selected and findings may not hold true for other (less well-supported) sites. Still, the rigorous evaluation approach, multiple data sources and ongoing data collection, the long evaluation period (12 months) and the integration into the existing national growth monitoring system through the posyandu provide robust scientific insights

and lessons for those working on mobile phone technology for nutrition monitoring systems. In Indonesia, the findings of the impact evaluation have prompted several external funders to support scale-up of the pilot to 150 additional urban posyandus. Further scale-up to rural sites is being planned.

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