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Mobile Phones for Real-time Nutrition Surveillance: Approaches, Challenges and Opportunities for Data Presentation and Dissemination

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MOBILE PHONES FOR REAL-TIME NUTRITION SURVEILLANCE: APPROACHES, CHALLENGES AND OPPORTUNITIES FOR DATA PRESENTATION AND DISSEMINATION

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1 Introduction

Child undernutrition remains devastatingly high in many low- and middle-income countries (Black *et al*. 2013). Poor nutrition in early childhood (often combined with ill health) has been shown to increase the risk for early mortality, can have long-term and often irreversible effects on physical growth, cognitive and social development, and increases susceptibility to non-communicable diseases in adulthood (Black *et al*. 2008; Liu *et al*. 2012; Victora *et al*. 2008). Effective nutrition surveillance mechanisms are essential if governments and other agencies are to capture undernutrition in its early stages, track undernutrition trends and inform timely decision-making (Gillespie *et al*. 2013).

However, nutrition surveillance is expensive and logistically laborious and therefore often non-existent in resource-poor countries (Jamison *et al*. 2006). Traditional surveillance systems are also constrained by time-consuming and error-prone paper-based data collection followed by manual data entry. Consequently, monitoring of nutrition in real time and a timely response to nutritional crises is often impossible. Mobile technology-enabled surveillance has the potential to improve data quality and achieve more complete data collection, allows faster and less human resource-intensive data collection. Data can be received and analysed more quickly and can thus inform decision-making in a timely manner. Moreover, data can be fed back to households and communities in ways that enable them to use the data.

Our initial desk-based review of available evidence found a huge and rapidly increasing interest in the use of mobile phone technology for real-time nutrition surveillance (Barnett and Gallegos 2013). There was also some (limited) evidence suggesting that mobile phone technology can facilitate more timely data collection and might help to improve the quality of the data. However, while there is a strong focus on real-time data collection and transfer (mainly driven by information and communication technology [ICT]), far less is known about what happens to the data once they are generated. How can real-time data be aggregated, presented and disseminated most effectively and appropriately to trigger rapid responses and increase accountability and commitment to addressing undernutrition? What are the potential challenges and barriers to the effective use of real-time surveillance data?

1.1 Aims and structure of the report

The aim of this report is to review and discuss approaches, opportunities and challenges in the aggregation, presentation and dissemination of data collected in a mobile phone-based nutrition surveillance system.

To this end the report will combine an overview of the principles and elements of nutrition and public health surveillance with:

- A review of the literature on real-time nutrition data presentation;
- Nine interviews with experts on mobile phone-enabled surveillance from NGOs, the private sector and intergovernmental organisations;
- An exploratory study visit to an ongoing pilot study on the use of mobile phones for community-based nutrition surveillance in Maharashtra, India.[1]

Mobile phone-based nutrition surveillance has many common elements with traditional paper-based nutrition surveillance and faces many of the same challenges and barriers. This report will draw heavily on the existing nutrition surveillance literature to position mobile

[1] The authors would like to thank Mr V Ramani, Rajalakshmi Nair (UNICEF) and KK Pal (Riddhi Management Services Pvt. Ltd) for facilitating the visit to the pilot sites of the JANANI mobile phone solution in Katol block, Maharashtra (www.janani.maharashtra.gov.in and http://nutritionmissionmah.gov.in/Pdf/Nomination.pdf).

phone-based surveillance within the wider surveillance literature. This report starts with a brief overview of types of nutrition surveillance systems and nutrition indicators collected in surveillance. Many of the opportunities and challenges to data processing, presentation and dissemination that are faced by traditional surveillance systems also need to be considered for mobile phone-based systems. This is followed by a description of the different stages of a nutrition surveillance cycle. For each stage, opportunities for data presentation and dissemination will be highlighted. With the introduction of mobile phone technology into surveillance, data can be shared in real-time or near real-time and at every step of the surveillance cycle, thus opening up new opportunities for data-informed decision-making. Section 4 will discuss different potential stakeholders of mobile phone-based surveillance data and their specific surveillance needs. This is followed by a brief presentation of two mobile phone software packages and their approach to data presentation. Section 5 will outline the ethical, technical and social issues in the presentation of real-time nutrition surveillance data. Finally, we consider the role a skilled intermediary might play in the analysis, interpretation, and communication of real-time data to make it more actionable for different stakeholders.

1.2 Methods

This report combines a synthesis of theoretical literature on public health and nutrition surveillance systems with a review of literature on real-time nutrition data presentation and dissemination, nine expert interviews and a study visit to an ongoing pilot study in India.

For the review, a search for grey and scientific literature on approaches and strategies to the presentation of real-time surveillance data was conducted in October 2013 using different databases (Web of Science, PubMed, Google Scholar, Google and HingX). Only very few studies on the presentation of real-time surveillance data could be identified and most of the retrieved literature focused exclusively on technical aspects of data collection and transfer and did not include details on the presentation of the data. Only two studies that examined mobile phone-based nutrition surveillance could be identified in the literature search (Berg, Wariero and Modi 2009; Blaschke *et al*. 2009). These findings echo the conclusions drawn by a recent review of the use of mobile phone technology for surveillance conducted by IDS (Barnett and Gallegos 2013).

For the expert interviews, the authors conducted nine interviews with experts on ICT and nutrition surveillance. Experts were initially identified via the personal contacts of the authors who then employed a snowball technique for the sampling (see Annex 1 for a list of the experts). Interviews were conducted in person, via Skype or email and cover experts' experiences and knowledge of the presentation of real-time surveillance data, perceived opportunities in the introduction of mobile phone technology into surveillance, and concerns about the use of technology in surveillance. Experts were also asked to share examples of the presentation of real-time surveillance data.

The field visit to the ongoing pilot study on the use of mobile phone technology was conducted in October 2013. As part of the visit the team conducted several focus group discussions with frontline health workers and caregivers and interviewed programme implementers and designers.

2 Real-time nutrition surveillance

2.1 Approaches to nutrition surveillance

Nutrition surveillance was originally defined as to 'watch over nutrition in order to make decisions which will lead to improvements in nutrition in populations' (Mason *et al*. 1984). It usually involves the ongoing and systematic collection, consolidation, analysis, interpretation and dissemination of information about the nutritional status of a population. Furthermore, ensuring that these information are linked up with appropriate and timely action (NutritionWorks 2011; WHO 2012). Box 2.1 presents some of the goals of nutrition surveillance.

Box 2.1: Common goals of nutrition surveillance

Common and overarching goals of nutrition surveillance are (NutritionWorks 2011; Roush 2011; Teutsch and Churchill 2000; WHO 2012; Yu and Robinson 2012):

- Inform decision-making with regard to nutrition;
- Identify nutritional patterns throughout the year (e.g. seasons);
- Identify nutrition hotspots and priority areas for nutrition action;
- Monitor the impact of programmes and interventions;
- Most appropriate allocation of resources;
- Detect decline in nutritional status early on (early warning system).

Different approaches to nutrition surveillance can be distinguished based on the methodological approach to the collection of data on nutritional status (Bilukha *et al*. 2012; NutritionWorks 2011):

- *Repeated nutrition surveys*: Cross-sectional surveys with randomly selected, representative population samples that are conducted in the same area every three, six or twelve months (small-scale surveys) or every three to five years (national-scale surveys).
- *Health facility-based growth monitoring*:[2] This approach makes use of routinely collected data on nutritional status from health care centres and clinics.
- *Sentinel site surveillance*: Periodic, cross-sectional collection of nutrition data from selected communities or health facilities. The sites are usually chosen based on predefined criteria – for example, an increased vulnerability – and can thus provide early warning of deterioration.
- *Rapid mass screening*: Periodic, exhaustive nutrition assessment of all children of a specific age in a selected locality. The aim is to capture all undernourished children eligible for treatment in a feeding centre.
- *Admission data from feeding programmes*: Data on the nutritional status of children admitted to therapeutic feeding centres. Captures only moderately and/or severely malnourished children.

The choice of which approach to select usually depends on purpose, available resources, context (e.g. emergency or stable context) and available capacity (NutritionWorks 2011). The different approaches vary with regard to the timeliness of data collection, with repeated surveys being the least timely approach (see Table 2.1).

[2] Some authors make a clear distinction between nutrition surveillance of a population group and individual-level growth monitoring, whereas others use the terms interchangeably.

Table 2.1: Key features of nutrition surveillance systems

Approaches	Frequency of data collection	Costs	Representa-tiveness	Timeliness of data reporting	Quality of anthropometric measures	Context
Repeated nutrition surveys	Periodic	High	High	Poor	Medium	Emergency/ stable
Health facility-based growth monitoring	Ongoing	Low	Medium (biased towards young children)	Poor–Good (centraliz-ation of data can take time)	Very good	Emergency/ stable
Sentinel site surveillance	Periodic	Medium	Low/High (depending on sampling)	Medium	Good	Emergency/ stable
Rapid mass screening	Periodic	High	High	Good	Good	Emergency
Admission data from feeding programmes	Ongoing	Low	Low	Good	Good	Emergency/ stable

Source: Adapted from Bilukha *et al.* 2012; NutritionWorks 2011.

Mobile phone technology has the potential to accelerate data collection and transfer in all approaches to nutrition surveillance (Tomlinson *et al*. 2009). However, with regard to timeliness, the value of mobile phone technology is likely to be especially high in surveillance systems with ongoing data collection, allowing for real-time or near real-time access to the data and immediate availability of data from different sites in one central database. In previous work that IDS has undertaken for the United Nations Children's Fund (UNICEF) in the context of real-time monitoring for the most vulnerable (Lucas, Greeley and Roelen 2013), real-time data collection has been defined as 'higher frequency of data collection or reporting, often using ICTs such as mobile phone technology'. Mobile phone technology has also been shown to be effective for rapid data transfer in emergency settings where the transport of paper-based data can be challenging due to security risks and destroyed infrastructure (Yang *et al*. 2009).

2.2 Use of nutrition indicators in nutrition surveillance

The collection of data on nutritional status is an essential part of nutritional surveillance. Surveillance systems usually collect a limited number of key variables on a frequent basis, whereas nutrition surveys collect a more comprehensive variety of nutrition and nutrition-related variables at single points in time. Table 2.2 presents nutritional assessment measures routinely used in nutrition surveillance.

Table 2.2: Anthropometric, biochemical/clinical and dietary indicators in nutrition surveillance

Type of measure	Purpose	Example
Anthropometry	To assess the nutritional status and identify energy deprivation and excess	For children: low weight for height (wasting), low weight for age (underweight), low height for age (stunting), MUAC[a] (wasting) For adults and adolescents: body mass index (BMI) For infants: low birth weight
Biochemical or clinical measures for micronutrient deficiencies	To identify micronutrient deficiencies	Low haemoglobin (iron deficiency anaemia), night blindness (Vitamin A deficiency)
Dietary assessment	To estimate food and/or nutrient intake	24-hour recall, food frequency questionnaire

[a] MUAC = middle upper arm circumference

Source: Authors' own.

Some surveillance systems also collect data on underlying factors of undernutrition, including household food security, access to services, socioeconomic status of the household, etc. (Shoham, Watson and Dolan 2001).

Nutrition indicators are usually presented by subgroups (e.g. age groups, infants, children, adolescents, women) as they will vary among different groups (LSHTM 2009). Children below the age of five years are particularly vulnerable to protein-energy-malnutrition (weight for height, weight for age, height for age), whereas adolescent girls and women are especially susceptible to micronutrient deficiencies (e.g. iron, iodine) (Shoham *et al*. 2001).

It has to be carefully considered which nutrition variables should be included in the surveillance system and which data will be useful and needed to inform decision-making. This is particularly so as information needs from nutrition surveillance systems are likely to vary between stakeholders and must be considered for data communication and presentation purposes (NutritionWorks 2011).

3 The nutrition surveillance cycle and opportunities for data presentation and dissemination

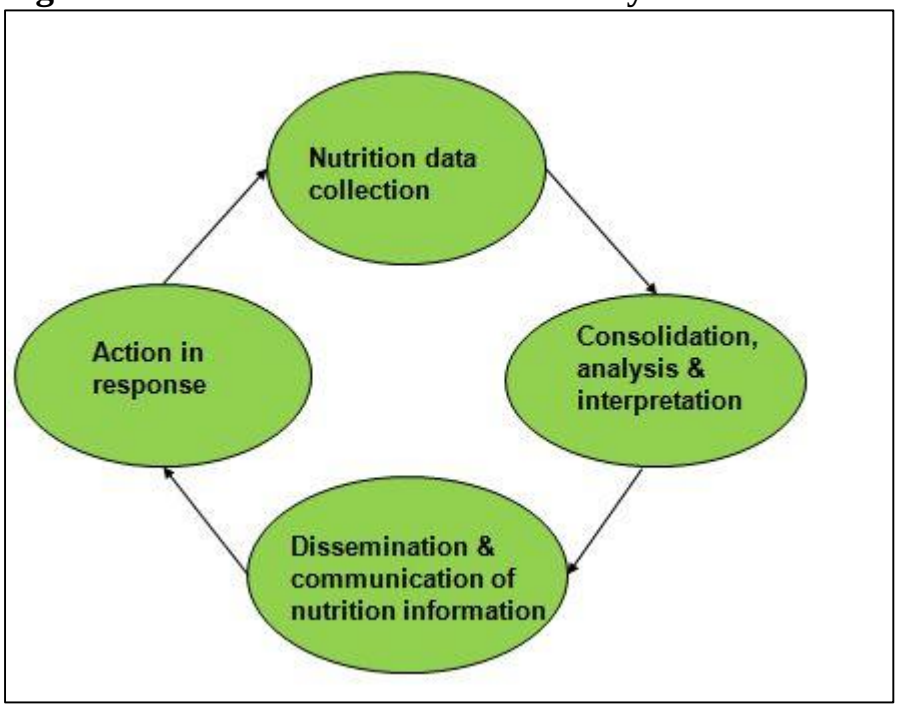
3.1 The four stages of the nutrition surveillance cycle

A surveillance system usually includes four major processes:

1. Data collection
2. Data consolidation, analysis and interpretation
3. Information dissemination
4. Action in response to data

Surveillance is often depicted as a cycle because it is undertaken continuously. The aim of ongoing surveillance is to capture changes and dynamics in a timely manner and trigger response (Maire *et al*. 2001; Thacker and Stroup 2003). Figure 3.1 illustrates the four stages of a nutrition surveillance system.[3]

Figure 3.1: The nutrition surveillance cycle



Source: Adapted from Thacker and Stroup (2003).

[3] Nutrition surveillance is also often presented using a triple-A cycle model (assessment of nutritional status, analysis of causes, action) (Jonsson 1995).

3.2 Data presentation and dissemination throughout the surveillance cycle

Data and information derived from nutrition surveillance can be communicated to relevant stakeholders at each stage of the surveillance cycle. The use of mobile phone technology for data collection, analysis and dissemination as part of nutrition surveillance offers additional opportunities for real-time or near real-time data aggregation, presentations and dissemination. In the following sections, key features of the four stages of nutritional surveillance will be outlined and, based on the findings from the literature and expert interviews, current approaches, opportunities and challenges will be discussed. The aim of the discussion is to highlight the opportunities and challenges for nutrition surveillance in general and mobile phone-based surveillance in particular. As emphasised previously, many of the threats and opportunities that are encountered by traditional surveillance systems also need to be considered in mobile phone-based surveillance.

In the surveillance literature a clear distinction between the terms ‘data’ and ‘information’ is made:

- *Data*: Describes the raw data collected via a mobile surveillance system prior to any aggregation, analysis and interpretation (e.g. weight and height measurements);
- *Information*: Describes data upon which some form of aggregation, analysis and interpretation has been applied (manually or automatically) (e.g. calculation of anthropometric indices).

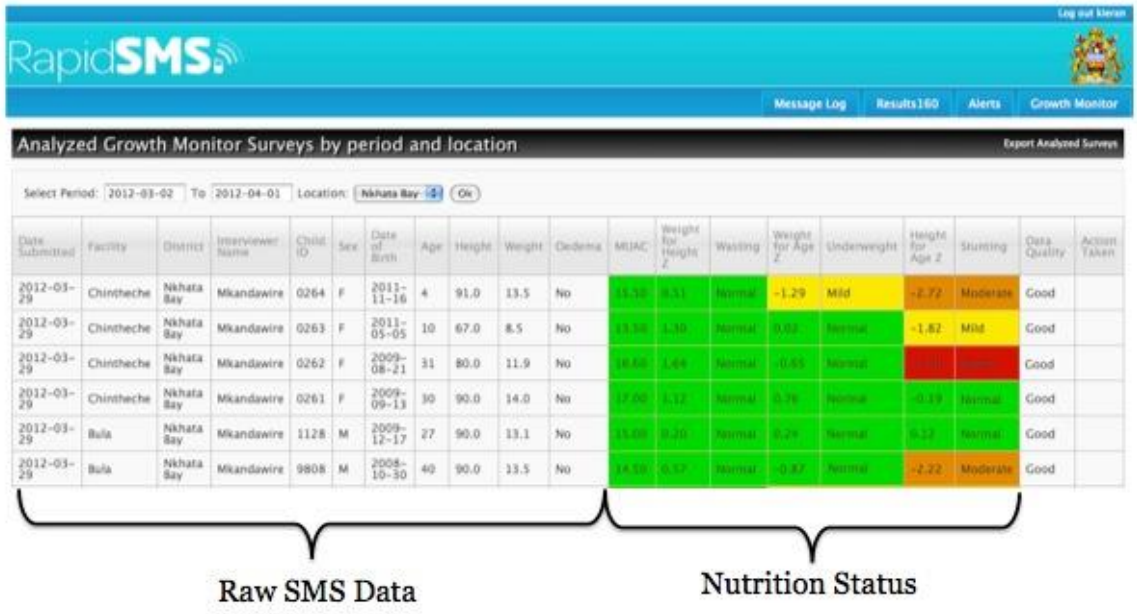
Stage 1: Nutrition data collection

In the first stage of nutrition surveillance, data on nutrition status (and potential other indicators) are collected from the population of interest (e.g. children below the age of five years). Data collection procedures and associated practical challenges (e.g. logistics, costs, timeliness) have long been discussed by surveillance experts and the donor community (Maire *et al*. 2001; Pelletier and Jonsson 1994). Mobile phone technology may help to address some of the challenges. For example, mobile technology has been shown to accelerate the process of data collection and transfer to the surveillance database (Barnett and Gallegos 2013). There are two options for how mobile phone technology can facilitate data presentation during data collection.

1. Presentation of data in the surveillance database

In mobile phone-based nutrition surveillance, the raw data on nutritional status and potential other indicators are available immediately after submission to the central database. The central database can be accessed by field supervisors, programme managers and other stakeholders to track the data collection in real time (assuming network coverage is available and accessible and data can be submitted). Figure 3.2 shows a screenshot of the database of a real-time nutrition surveillance system supported by the RapidSMS nutrition application ‘AnthroWatch’ (www.rapidsms.org). The first part of the data presented in the figure are the unprocessed raw data. In the second part the data were processed into more meaningful information. Nutrition indices were calculated by comparing anthropometric measurements with the appropriate age- and gender-specific World Health Organization growth charts.

Figure 3.2: Presentation of raw data and nutrition information on a user dashboard in a mobile phone-based surveillance system (screenshot)



Source: RapidSMS (www.rapidsms.org). Published with permission from UNICEF.

Access to real-time nutrition data on the dashboard has been shown to be an effective tool to monitor health care workers' performance and location (if a GPS-enabled phone is used) during the data collection (Barnett and Gallegos 2013). For example, low performance (e.g. low number of nutritional assessments performed per day) can immediately be followed up by the field supervisor.

2. Presentation of data on the mobile phone screen

Most mobile phone applications process anthropometric measurements immediately after entry and calculate nutrition indices. This can happen via an automated feedback loop between the phone and the server or as part of an integrated feature of a software package. Nutrition indices are fed back to the frontline health worker via text message or directly on the phone screen and can facilitate individual case management of a child (Berg *et al*. 2009; Blaschke *et al*. 2009). Nutrition indices of the individual child can also be communicated directly to the caregiver to make her/him aware of the child's nutritional status and empower her/him to take action.

While mobile phone technology offers the potential for immediate data presentation and communication on the ground, several of the interviewed experts described how the realities of data collection frequently prevent frontline workers from using this feature. One expert described how some frontline workers were reluctant to provide immediate information on the nutrition indices of the individual child to the caregiver. The health workers explained that the busy and often overcrowded surroundings of the health facility did not provide any privacy and also did not allow any time for counselling the mother. Leaving caregivers with the devastating message that their child is underweight without directly offering context-specific solutions based on a careful analysis of underlying problems was perceived as unethical. Familiarity with the application and readability of the screen were cited as barriers to the use of data presentation options onscreen. One expert described how many frontline workers (especially older workers who were less experienced in using technology) preferred to collect the data using pen and paper as this was faster. Data entry and transfer took place after hours or on the weekend when there was more time to concentrate on the screen. This observation was supported by the reviewed literature (Gow, Waidyanatha and Mary 2010).

Another expert added that many of the frontline workers struggled with the readability of the small screen (especially in direct sunlight) and felt that the necessary focus on the screen affected their direct interactions with the caregiver.

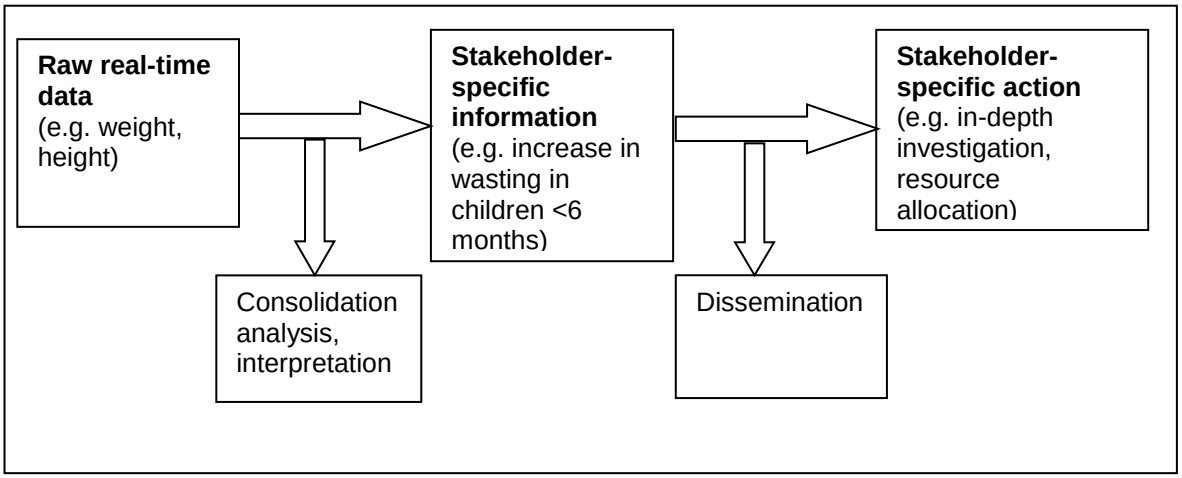
Data presentation on the mobile phone screen was usually limited to the presentation of data on the individual child. Aggregated data, for example a table or graph on the distribution of undernutrition across eligible children in the community, were usually not presented.

While the direct presentation of data and nutrition indices can be effective in improving nutrition service delivery at the grass-roots level, sharing of large amounts of individual-level data is less useful for policymakers and government officials (D.E. Nelson *et al*. 2002). To convey nutrition surveillance data effectively and to increase the likelihood of a response, data need to be aggregated and interpreted within the context.

Stage 2: Consolidation, analysis and interpretation

While access to raw data can provide some immediate insights into changes in the nutritional status of a population of interest, some degree of processing is necessary in order to understand and interpret the real-time data correctly and appropriately within a specific setting. Figure 3.3 illustrates the process that transforms raw nutrition surveillance data into information that can then trigger action.

Figure 3.3: The process from raw data to information to action



Source: Adapted from WHO (2013).

The surveillance literature stresses that data usually ‘can’t speak for themselves’ and ‘need to be looked at’, translated and interpreted to lead to an appropriate action (Remington and Nelson 2010; Roush 2011). Maire *et al*. 2001 commented that most nutrition surveillance systems focus mainly on the data (and merely become ‘massive anthropometric data collection’ systems) and less on the information that can be drawn from the data. Effective data presentation needs to be based on a thorough understanding of the data, what the data mean and how they are interpreted most effectively.

The presentation of surveillance data in a consolidated form (e.g. in the form of summary tables, graphs that show trends over time, geographical maps) has been shown to be more effective in conveying information, as the human brain struggles to comprehend too much data at one time (D.E. Nelson *et al*. 2002). Processing real-time raw data is time-consuming but needs to happen to ensure actionable information for different relevant stakeholders. To get a better understanding of why observed changes in nutritional status may have occurred and to determine what action would be most appropriate, a customised analysis of the data

is usually necessary. While some automated data analysis and report writing is usually possible, context-specific interpretation of nutrition data by humans (rather than automated) is important to ensure correct understanding of the data and to facilitate decision-making that is appropriate and relevant for the setting (Roush 2011).

Nutrition surveillance data, independently of whether the data are collected using pen and paper or mobile phones, are usually consolidated, analysed and interpreted by time, place and child characteristics (e.g. age range, sex). The use of predetermined threshold levels (e.g. cut-offs for the prevalence of wasting in a population to determine severity levels [de Onis and Blössner 1997]), trend analysis, comparison with expected values and with data from other communities and districts are also common approaches.

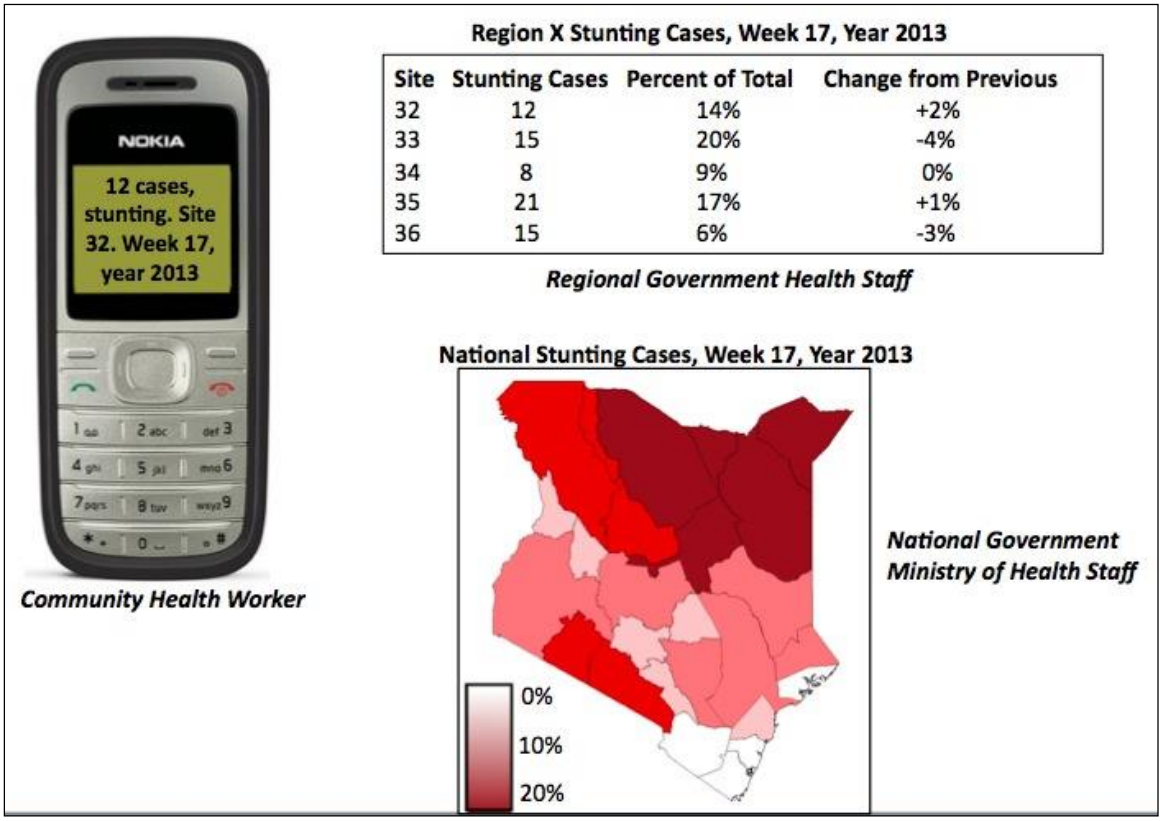
Interpretation of real-time nutrition data also needs to include a judgement on the quality and trustworthiness of the data. Collection of reliable anthropometric measures is difficult and has been shown to be affected by errors and various biases (Gibson 2005; Ulijaszek and Kerr 1999). Careful data checks are therefore necessary to avoid an unnecessary waste of resources in response to unreliable data. Issues relating to data quality and trustworthiness are discussed later in this paper but often extend beyond inaccurate measurements and can include deliberate under-reporting/over-reporting (e.g. due to fear of penalties, resource cuts).

Stage 3: Dissemination of information

Information derived from the surveillance needs to be consolidated, interpreted and disseminated in a timely manner and in an appropriate format to maximise the potential for uptake. Our literature review and interviews suggest that most existing mobile phone-based surveillance systems focus on the technical features of data collection and how to further strengthen and accelerate this first stage of surveillance (Barnett and Gallegos 2013). In this context, one expert also highlighted that the ICT expertise necessary to collect and analyse surveillance data is likely to be very different from the skills necessary to communicate and disseminate real-time surveillance data effectively. Currently, far less attention is being paid to the development of approaches to effective dissemination of surveillance information (Barnett and Gallegos 2013). In fact, surveillance information seems to be used mainly to facilitate programme management, identify and treat undernourished children and support service delivery at the grass-roots level. Nevertheless, dissemination of surveillance information to national-level decision-makers, integration of mobile phone surveillance into national surveillance efforts and information-sharing with other stakeholders (e.g. other agencies) were frequently mentioned as long-term goals and were perceived as essential to ensure sustainability.

Concrete dissemination approaches were often less developed and many systems mainly targeted the employees of the agency or department that operated the surveillance system. Several experts (researchers, private sector and government agencies) demonstrated geographical mapping tools for the presentation of aggregated district- and national-level surveillance data. These approaches were often interactive and could highlight trends, local distributions of undernourished children and more. Geographical mapping can be a powerful tool for trend analysis and to guide identification of ‘hunger hotspots’ – areas that are particularly vulnerable to undernutrition (see Figure 3.4 for an example of nutrition information mapping derived from a mobile phone-based surveillance system). However, mapping has to be based on spatially accurate data, precise location information and representative samples (Ward 2007). In areas with heterogeneous population densities (e.g. in urban areas), geographical mapping can be misleading in drawing attention and resources to areas that might not be the most vulnerable (Remington and Nelson 2010).

Figure 3.4: Example of geographical mapping of mobile phone-based surveillance data



*Note: Map in figure above is not intended to reflect actual administrative boundaries.

Source: © Mala Kumar (2013), for RapidSMS, Anthrowatch.

The traditional nutrition surveillance cycle presents the dissemination of surveillance information in a unidirectional process whereby the surveillance information (collected by frontline workers and analysed/interpreted by the agency/organisation that operates the surveillance system) is disseminated to the policymaker. This approach fails to provide a mechanism whereby the information supplier and the potential information consumer can interact to develop an increased mutual understanding of information demand and supply. Iterative communication mechanisms can be more effective for influencing policy decisions (Dilling and Lemos 2011). Reframing the dissemination link in the nutrition surveillance cycle to a form of communication where there is push and pull of information between provider and consumer would increase the likelihood of information affecting policymaking (Harvey, Lewin and Fisher 2012; Jones *et al.* 2012).

Several of the interviewed experts pointed out that most policymakers and government officials are not yet familiar with the use of real-time data to inform their decision-making processes. Doubts about the quality of data and information derived from existing nutrition surveillance were perceived as an additional barrier to data use. The experts (Johnson, Phong and Wheeler – see Annex 1) emphasised a need to sensitise stakeholders and to make them receptive to the existence of better-quality, real-time nutrition surveillance data. Remington and Nelson (2010) describe the importance of performing active 'marketing' for surveillance data to raise interest and trigger timely action. While actively promoting real-time nutrition data, it is important to also consider stakeholders' capacity to engage with and critically assess the quality and validity of the information presented and apply it (Datta *et al*. 2011). A better understanding of stakeholders' real-time data literacy and their potential and

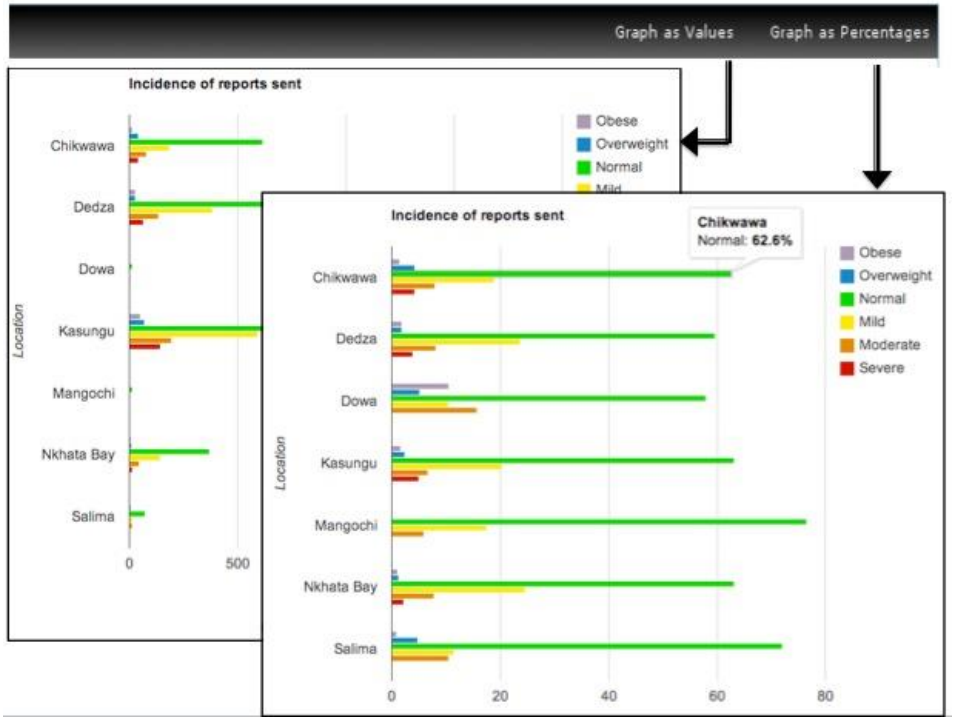
abilities to take up real-time data is essential to manufacture effective dissemination strategies.

While increasing awareness and illustrating the value of real-time data is important, it is equally or even more important to actively create a demand for data (e.g. via effective and tailored dissemination strategies) to inform decision-making for nutrition. This is likely to be extremely challenging, especially as many countries do not have a well-established culture of data-informed decision-making for health and nutrition (Pelletier *et al*. 2012).

To disseminate surveillance information effectively, approaches and communication channels need to be chosen based on the intended audience (D.E. Nelson *et al*. 2002). Dissemination of surveillance information can be passive (e.g. via regular newsletters or bulletins) or active (e.g. direct feedback loops). Active dissemination strategies that involve some kind of two-way interaction between the sender and the receiver have been shown to be most effective in initiating action (D. Nelson, Hess and Croyle 2009; Remington and Nelson 2010). Moreover, Halperin *et al*. (1992) found that the dissemination and uptake of surveillance information was more successful if combined with stakeholder-specific suggestions/advice (Halperin, Baker and Monson 1992). The provision of additional information and interpretations (e.g. via messages sent together with the data) has also been shown to prevent unintended reactions to the surveillance data such as denial, fear, helplessness or misunderstandings (Halperin *et al*. 1992; D. Nelson *et al*. 2009).

Visual presentations of surveillance information can be effective in communicating changes and temporal trends. Visually attractive graphics, maps and charts are usually more effective than tables or pure text because audiences generally find them more engaging and, if done well, easier to understand (Sullivan *et al*. 2010). See Figure 3.5 for an example of data visualisation of mobile phone-based surveillance. No evidence on how different types of visual presentations are taken up by different audiences could be identified.

Figure 3.5: Example of visual presentation of aggregated data collected in a mobile-phone-based nutrition surveillance system



Source: Mala Kumar (2012), for AnthroWatch. Published with permission from UNICEF.

To avoid misinterpretation of the information and a waste of resources, visual presentation always needs to be combined with a careful context-specific analysis and interpretation of the data. The quality of the data (e.g. reliability of the anthropometric measures), type of surveillance (passive or active) and sampling approach are also important factors to consider for correct data visualisation.

Innovative approaches to surveillance information dissemination such as real-life stories of children and their households can be a persuasive approach to initiating action but are seldom used in the field as they are usually very time- and resource-intensive (Stachenko 2008).

To sum up, it appears that challenges to the dissemination of real-time surveillance information are not so much about presentation but more about alignment, interpretation and real-time data literacy.

Stage 4: Action in response

The main purpose of nutrition surveillance is to highlight issues that require attention and action (Mason *et al*. 1984). Collection of large amounts of anthropometric data without a response is unethical and a waste of resources. What counts as an appropriate response to real-time surveillance information depends on the stakeholder (e.g. primary caregiver, health worker, programme supervisor, national-level politician), context and needs, whether it is an emergency setting or stable context, available resources and human capacities. Pelletier and Jonsson (1994) emphasised that supplying information via nutrition surveillance does not lead to automatic behaviour changes or improved decision-making processes with regard to nutrition. Decision-making structures are intrinsically embedded in the political economy dynamics and context of a country and thus decisions are usually influenced by a multitude of factors, actors and interests (Balarajan and Reich 2012; Datta *et al.* 2011; Newman *et al.* 2013). To be effective it is important that the mobile phone-based nutrition surveillance system is integrated into a broader nutrition strategy and is not a stand-alone measure. For example, health facility-based growth monitoring can only improve child nutrition when combined with nutrition promotion and treatment options for malnourished children (Bryce *et al.* 2008).

The surveillance literature suggests that surveillance information is most effective if combined with active strategies of encouragement and specific plans of action in response to issues highlighted by the data (Jonsson 1995; Maire *et al*. 2001; D. Nelson *et al*. 2009; D.E. Nelson *et al*. 2002; NutritionWorks 2011; Pelletier and Jonsson 1994; Thacker *et al*. 2003). Our previous literature review of mobile phone-based surveillance systems came to a similar conclusion (Barnett and Gallegos 2013). It found that public health surveillance was most effective when it employed clear thresholds for action and used predefined operational response procedures (Safaie *et al.* 2006). Appropriate plans of action vary depending on the respective stakeholder and context. For community-level health workers it could include a referral protocol for the admission of acutely malnourished children to a selective feed programme. For national-level governments and intergovernmental organisations, passing of predetermined context-specific alert thresholds for the proportion of acutely malnourished children could automatically trigger relief distribution of foods as well as a detailed nutrition survey to investigate the underlying causes for the observed decline in nutritional status (NutritionWorks 2011). It is important to revisit these plans of action regularly and adjust or refine them to reflect contextual changes as necessary (Pelletier and Jonsson 1994). No evidence on the potential impact of the way data are presented on the likelihood of response or type of action taken could be identified in our review or during the interviews.

The literature and three of the interviewed experts suggest that mobile phone-based nutrition surveillance currently seems to be most effective in triggering response at the level of the individual child and the community (e.g. via direct feedback to the frontline worker) (Berg *et al*. 2009; Blaschke *et al*. 2009). There is less evidence and documented experiences on how to integrate information derived from real-time nutrition surveillance into higher-level decision-making processes (Wheeler – see Annex 1).

4 Presentation of data to different stakeholders of real-time nutrition surveillance

4.1 The potential stakeholders of nutrition surveillance

Information and data from nutrition surveillance can be used by a large and heterogeneous group of stakeholders. Some of these stakeholders are actively involved in the surveillance process (e.g. frontline health workers who collect the data, agencies that analyse the data), whereas others are mainly the recipients of information (e.g. policymakers). Stakeholders vary with regard to the availability and control of resources (e.g. nutrition budget), capacities and decision-making power (Maire *et al*. 2001; Pelletier and Jonsson 1994; Pinstrup-Andersen 1993; Tiefu and Habicht 1991) Table 4.1 summarises different potential stakeholders of mobile phone-based nutrition surveillance and their needs.

Table 4.1: Stakeholders of mobile phone-based nutrition surveillance and their needs

Stakeholder	Surveillance needs[a]
Different government ministries (health, nutrition, agriculture, development, trade and commerce, statistics)	e.g. facilitate policy planning, inform resource allocation, document and monitor progress, provide early warning for nutrition crisis, estimate magnitude and distribution of undernutrition
Health/nutrition sector (national, district and local level)	e.g. inform programme and policy development, monitor nutrition service delivery and health worker performance, monitor population at risk
Non-governmental organisation (local, national and international)	e.g. advocacy, facilitate programme planning and monitoring, document progress, identify populations at risk
Intergovernmental organisation (e.g. Food and Agriculture Organization (FAO), UNICEF, WHO)	e.g. inform resource allocation, estimate magnitude and distribution of undernutrition, progress monitoring, accountability
Bilateral donors and other donors	e.g. inform resource allocation, estimate magnitude and distribution of undernutrition, progress monitoring
Academic institutions	e.g. setting research direction and priorities, teaching

Table 4.1 Cont'd.

Media	e.g. informing general public, raise awareness
Private sector (e.g. food industry, mobile phone operators)	e.g. marketing, new customers
Local community	Primary caregiver: e.g. monitoring progress of individual child, feels empowered by information General community: e.g. inform and raise awareness for nutrition Frontline health worker: facilitate and monitor case management, feels supported and empowered

[a] This is not an exhaustive list of the potential nutrition surveillance needs for each group of stakeholder. Needs are likely to vary depending on the context and need to be assessed for each surveillance system individually.

Sources: Adapted from Brownson and Malone (2002); Teutsch, Teutsch and Churchill (1994); WHO (2013).

It is important to include the frontline health worker in the list of stakeholders. They are responsible for data collection and entry and conduct the anthropometric measurements. Many surveillance systems focus strongly or even exclusively on data collection and transfer 'up the chain' while communication back to the field team (and the primary caregivers) is still rare (Raftree 2013). To ensure a sustainable real-time surveillance system once the initial novelty of and excitement with the mobile phone technology has worn off, constant feedback and encouragement of the field team is critical (expert interviews).

4.2 The importance of stakeholder-specific data presentation

Generally, the more widely information derived from a nutrition surveillance system is disseminated, the more likely it is that it will be utilised and initiate action (D.E. Nelson *et al*. 2002). New communication channels (e.g. social media) and innovative data distribution strategies (e.g. RSS feeds)[4] make fast and inexpensive sharing of nutrition surveillance information possible. However, the effectiveness of a surveillance system has been shown to increase significantly if the presentation and communication of data and information are tailored to the specific needs and abilities of each group of stakeholders and when there is a two-way interaction between sender and receiver of the information (Remington and Nelson 2010).

Needs with regard to both breadth and depth of information required from nutrition surveillance have been shown to vary considerably between stakeholders and contexts (Jonsson 1995; Maire *et al*. 2001; Roush 2011). For example, a frontline health worker might be interested in the nutritional wellbeing of individual children and wants to know how she/he can improve the local nutrition situation. National-level data on child undernutrition may be less useful (although comparison might help the worker to discern where to place him/herself). Data on the regional distribution of undernutrition in a country may be highly relevant for a national-level politician, for instance, to guide the allocation of national health and nutrition resources. Data from the individual child or community level are likely to be less useful to this national-level stakeholder group.

Stakeholders also differ with respect to their preferences and capacities to make use of different formats of surveillance information and to access different communication channels (e.g. due to access to electricity, WiFi, information literacy, etc). Complex graphics and maps

[4] RSS (rich site summary) uses standard web feed formats to deliver frequently changing website content. It helps users keep track of new and developing website content.

of surveillance data might be effective advocacy tools for government ministers and donors, but may intimidate and confuse frontline health workers and primary caregivers at the local community level who may lack the mathematical skills to interpret these presentations (D.E. Nelson *et al.* 2002). Oral dissemination of surveillance data, for example, during team meetings between frontline workers or directly to the caregiver, has been shown to be effective at the community level (Berg *et al*. 2009; Blaschke *et al*. 2009). During the field visit and in discussions with frontline workers, handwritten tables and blackboards positioned inside or outside the community-level health facility were mentioned as effective communication channels of aggregated surveillance data collected through mobile phones. One expert described how the names of all children who were identified as moderately or severely malnourished during the monthly growth monitoring sessions were publicly announced in a written notice. This approach aimed at raising awareness and encouraging the community to take joint responsibility for an undernourished community member. Of course, this approach is very culture-specific and publicly 'naming and shaming' caregivers with undernourished children is unlikely to work in all settings.

Stakeholder needs and ability to receive nutrition surveillance information including different formats of surveillance information is also influenced by the social, cultural, political and economic environment in which the surveillance system is located (Pelletier and Jonsson 1994). For example, in settings where nutrition-related decision-making is based on historical nutrition survey data, economic evaluation, recommendation of an expert panel or the wishes of different interest groups, needs for surveillance data are limited (Choi *et al*. 2005).

In conclusion, the effective presentation of surveillance information has to start with a thorough and context-specific analysis of each stakeholder's needs, abilities and resources. Ideally, stakeholders should be actively consulted and involved in the development of data presentation tools. Only they can say which indicators of nutrition they are interested in tackling, which data would be most relevant for their requirements, and which they will use in the long term (D.E. Nelson *et al*. 2002). Without a clear purpose and benefit for the different stakeholders, sustainability of surveillance is likely to be very low (Teutsch and Churchill 2000).

5 Ethical, technical and social challenges to the presentation of real-time nutrition surveillance data

There are several challenges to the dissemination and presentation of real-time data. Some of these challenges are specific to mobile phone-based systems, whereas others are challenges of general surveillance systems that also need to be considered in mobile phone-based systems.

5.1 Ethical issues

Data security and confidentiality remain important especially if global positioning system (GPS) data and/or photos of children are collected (Raftree 2013; Teutsch and Churchill 2000; Thacker *et al.* 2003). The introduction of mobile phone technology and other ICTs into nutrition surveillance may heighten data confidentiality issues further, as data-sharing can occur more quickly and data access is often less controlled and guarded.

An ethical presentation of data from real-time surveillance systems also includes the avoidance of over-interpretation and exaggeration (e.g. via graphic presentations) (D. Nelson *et al*. 2009). Unintended consequences could include, for example, frustration and feeling of powerlessness among frontline health workers if real-time surveillance data frequently highlight problems but there are no resources (human, financial) or decision-making powers to react to the issues highlighted. This would ultimately lead to loss of credibility of the surveillance system. For a comprehensive discussion of general ethical issues in health surveillance see, for instance, Heilig *et al*. (2010).

5.2 Data quality

Mobile phone technology has been shown to be effective in reducing data entry errors and thus improving the accuracy of surveillance data (Barnett and Gallegos 2013). However, challenges remain. Collection of accurate, reliable nutrition data and especially anthropometric data is not easy. Small measurement mistakes can have a huge impact on the categorisation of a child's nutritional status (e.g. a child is classified as malnourished when in fact it is not). Other challenges are over-reporting of levels of undernutrition, for example if the level of child undernutrition determines the budget allocation to a health facility, or deliberate under-reporting, for example if health care staff are penalised for reporting high levels of undernutrtion in the facility they are responsibe for (Awofeso and Rammohan 2011).

5.3 Representativeness of surveillance systems

In systems that are focused on children, surveillance can only provide data on children whose nutritional status is assessed. It does not provide an estimate of the population denominator (i.e. estimate of the total number of children) (Maire *et al*. 2001). This is particularly problematic in unstable settings where populations are changing constantly. As a consequence it is not possible to calculate the incidence rates.

5.4 Incomplete reporting and consequent over- or under-reporting of undernutrition

Participation in mobile phone-based nutrition surveillance relies on active participation and data collection and transmission by health workers. In overstretched healthcare systems with overworked staff, mobile phone-based nutrition surveillance can place an additional burden on the health workers (e.g. lack of familiarity with the technology, need to learn how to use the technology can trigger fear, need to remember to regularly charge tool, risk of theft) and can lead to an underestimation of the burden of undernutrition. Surveillance systems that rely on monthly growth monitoring at health facilities might be affected by a caregiver's inability or unwillingness to present the child at the health care facility for measurement on a monthly basis.

5.5 Changes in the context

Local contexts of real-time nutritional surveillance systems have to be monitored carefully to capture eventual changes accurately. For example, a decline in reported cases of acute malnutrition by a health care facility might be due to an improvement in nutrition and living environments in the community. However, it can also be result of emigration of households from the community (e.g. for seasonal labour) and a consequent decline in the number of children in the community. The temporary closure of a health facility in a region, for example due to limited supply or lack of staff, might also result in changes in the prevalence of undernutrition without real changes in the community (LSHTM 2009).

6 Conclusion

The objective of this report was to review and discuss approaches, opportunities and challenges in the dissemination and presentation of data collected in a mobile phone-based nutrition surveillance system. To achieve this the report combined a review of literature on real-time nutrition data presentation, interviews with experts on mobile phone-enabled surveillance and a study visit to an ongoing pilot study .

The report found the following:

- Mobile phone technology offers new opportunities to present surveillance data and information throughout the surveillance cycle.
- Different stakeholders have different surveillance needs. These needs must be assessed and addressed to ensure sustainable demand for and use of surveillance data.
- Surveillance data can't speak for themselves but need to be interpreted and set within context. This is especially important if data will be used to inform decision-making at national level.
- Effectively customised data presentation and visualisation are important, but the human aspect of data transfer, analysis and dissemination is necessary to ensure actual data uptake.
- It is impossible to develop a one-size-fits-all tool that can be employed for data presentation and dissemination in different settings. Data presentation needs to be based on careful context-specific analysis of stakeholders' needs, abilities and capacities.
- Most mobile phone-based surveillance systems focus mainly on the acceleration in timeliness and quality improvement of data. Data presentation and dissemination in an actionable way receive far less attention.

Annex 1: List of contacts

Name	Organisation	Organisation role	Contact
David Aylward	Ashoka	Senior Advisor, Health and Technology	Email, Skype
Erica Kochi	UNICEF Innovations	Co-Lead	Email
Friday Nwaigwe	UNICEF	Chief of Health, Rwanda	Email
Robert Johnston	UNICEF	Nutrition expert	Email, Skype
Piyali Mustaphi	UNICEF	Head of Nutrition, Malawi	Email, Skype
Evan Wheeler	UNICEF	Coder, AnthroWatch; lead software developer	Email, Skype
Elizabeth Anne Ali	Amadeyr	Chairperson	Email, Skype
Philip Phong	FAO	ICT expert	Skype
KK Pal	Rhiddi Management	ICT expert	In person

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