TRANSFORMING THE SUPPLY CHAIN

Mobile Technology for Data Collection in the Health Supply Chain: Case Studies and Shared Learnings from Low- and Middle-Income Countries

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Acronyms

ACT	Artemisinin-based Combination Therapies
ART	Anti-Retroviral Therapy
CCM	Community Case Management
CHA	Community Health Assistant
CHV	Community Health Volunteers
DFAT	Department of Foreign Affairs and Trade
DMA	Drug Management Agency
e-LMIS	Electronic Logistics Management Information System
EPSA	Ethiopian Pharmaceutical Supply Agency
eVIN	E-Vaccine Intelligence Network
EWS	Early Warning System
FEFO	First Expiry, First Out
FRHP	Focus Region Health Project
GIS	Geographic Information System
GPRS	General Packet Radio Services
HCD	Human Centered Design
HCMIS	Health Commodity Management Information System
HMIS	Health Management Information System
HSA	Health Surveillance Assistants
IAPHL	International Association of Public Health Logisticians
ICT	Information and Communication Technology
ILS	Integrated Logistics System
IT	Information Technology
ITSU	Immunisation Technical Support Unit
JSI	John Snow, Inc
LMIS	Logistics Management Information System
PSA	Pamela Steele Associates
RFID	Radio-Frequency Identification
SMS	Short message Service
TB	Tuberculosis
UNDP	United Nations Development Programme

UNFPA	United Nations Population Fund
USAID	United States Agency for International Development
USSD	Unstructured Supplementary Service Data
WHO	World Health Organisation

1. Executive Summary

Data plays a critical role in the Health Supply Chain and has attracted increasing attention in recent years. The flow of data in LMIC's is often hindered, and many countries are reliant on burdensome and more inaccurate methods of paper-based data collection. At the same time, mobile technologies are acknowledged as one of the most successful methods of data collection, and the use of mobile technologies is rapidly rising in LMICs; African countries have the fastest growing mobile market in the world. This report therefore focuses on the use of mobile technologies to improve the Health Supply Chain in low and middle-income countries (LMICs), drawing on nine case studies of mobile technologies to create overall conclusions and recommendations. The information is gathered through a desk review, an online survey conducted by Pamela Steele Associates (PSA) with over 100 Supply Chain professionals and interviews with key informants.

Part One of this report includes a literature review and summary of survey results. This emphasises the importance of visible, high-quality data for the Health Supply Chain and outlines the context of often low data visibility in LMICs. It presents mobile technology as a solution to this, highlighting the benefits of this approach which can help to transmit data, and store and compute information. The literature review concludes by highlighting some common barriers faced during the implementation of mobile technology, including its sustainability, human resourcing and infrastructure issues, as well as a lack of integration.

Part Two uses a case study approach to explore examples of mobile technology interventions. Nine case studies are referenced: SMS for Life 1.0, SMS for Life 2.0, e-Vaccine Intelligence Network (eVIN), mSupply Mobile, CommCare Supply, Rapid SMS, DHIS2, mBrana and medPRO. Each of these case studies includes an overview of the technology and how it works, information about how it was implemented, and where sufficient information is available, key factors for sustainability and lessons learned from the intervention.

This study then draws together the case studies to create shared learnings and recommendations. These include the benefits that mobile technologies have brought to the Health Supply Chain in LMICs (such as increased stock availability, stock visibility and increased reporting) as well as the challenges that they faced. These challenges include costliness, inadequate training or staff time to input data, and connectivity challenges. It provides recommendations for how these can be overcome, such as providing ongoing training and considering the country's infrastructure and the technical specification of the app. Most importantly, any new technologies should be integrated with the existing technologies and health system and should be implemented in conjunction with other Supply Chain strengthening measures.

2. Introduction

Data plays a critical role in the Health Supply Chain. It helps to plan procurement, monitor stock consumption, and assess the performance of the end-to-end Supply Chain, amongst many other things. It is an area that has attracted increasing attention in recent years, though the flow of health data and Health Supply Chain data in many LMICs is still hindered. Low-income countries are often reliant on paper-based methods of data collection, which tend to be more burdensome and inaccurate.

At the same time, African countries have the fastest growing mobile market in the world (Subramanian, Steele and Tolani, 2020). There were 456 million unique mobile subscribers in Sub-Saharan Africa in 2018 and it is predicted that the subscriber base will be just over 600 million by 2025 (GSMA, 2019). Mobile technologies are widely acknowledged as one of the most successful methods of data collection and have been used for decades in enhancing Supply Chain Management, and are now increasingly being applied to smaller health systems in LMICs (Roess, 2017). Mobile technology can help to transmit and communicate data, store information in a standardised format and compute information.

In the last decade, numerous pilots and interventions have been implemented in the field of mobile technology for Health Supply Chain for LMICs, often with donor support. Examples of this technology include applications (apps) which help monitor stock and disease surveillance data, provide an electronic medicine inventory, provide a service for ordering drugs or a standardised price list. The pilots often record positive effects, though have also struggled to effectively scale up and can remain siloed and unsustainable.

Whilst research into general mobile technologies for health (mHealth) is prolific, research specifically concerning mobile health technology and the Health Supply Chain is more limited. Existing research often evaluates the impact of one specific programme or pilot. This study aims to address this gap by adopting a broader approach, focusing on Health Supply Chain mobile technologies and interventions across a range of countries from the last ten years. This includes programmes in India, the Pacific Islands, Ghana and many more countries. After examining case studies, this study identifies lessons learned and recommendations from the different interventions and summarises these to create joint conclusions.

3. Methodology

This paper begins with an extensive literature review of mobile technology for Health Supply Chain and related areas, including the importance of data visibility for a strong Supply Chain, the data visibility context in LMICs and benefits and challenges that the greater use of mobile technologies for Health Supply Chain will bring. PSA additionally conducted a 35-question online survey in August 2017 through the SurveyMonkey application. Respondents were from the International Association of Public Health Logisticians (IAPHL), an international Supply Chain network, and included 113 Supply Chain professionals from more than 20 countries. The condensed survey results, alongside a recent (2020) literature review, are available in section 1 of this report.

To further explore the practical experience of implementing mobile technology programmes, and to learn from real-life interventions, PSA also examined various mobile technology Health Supply Chain projects. These are included in Part 2 of the report, utilising a desk review as well as interviews and questionnaires conducted with experts with experience of certain case study mobile technologies. For these interviews, questionnaires were sent to the respondents, who then completed these and their responses were discussed during an interview. Each case study includes an introduction outlining the basic technical aspects and context for the technology, example(s) of implementation, and where available, information on sustainability of the technology and recommendations or lessons learned. The mobile technologies used as case studies are outlined in the table below:

Table 1 Country Intervention Examples Provided for Each Mobile Technology Case Study

Mobile Technology Case Study	Intervention Examples Included in Case Study
SMS for Life 1.0	Tanzania, Kenya
SMS for Life 2.0	Nigeria
eVIN	India
mSupply	Solomon Islands, Timor Leste
CommCare Supply	Ghana
Rapid SMS	Tanzania, Malawi
DHIS2	Kenya
mBrana	Ethiopia
MedPRO	Nigeria

Limitations

The examples of mobile technologies listed in Part 2 are not exhaustive. Numerous mobile technologies operate within specific projects or countries, making it challenging to capture them comprehensively. Rather, the case studies show a snapshot of the kinds of mobile technologies used in the Health Supply Chain, alongside examples of their use. Other kinds of technologies, such as blockchain, also show the potential to strengthen and change the Supply Chain, though this paper focuses on mobile technology due to the breadth and prevalence of this theme.

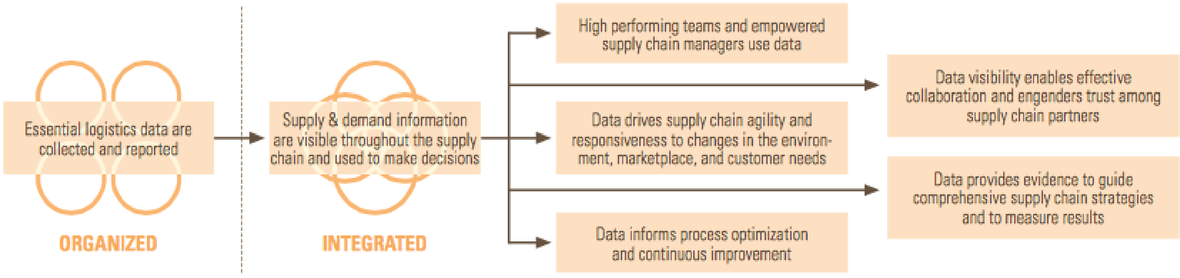
A substantial amount of the literature available on mobile technology for the Health Supply Chain is published by the organisations overseeing, funding, or implementing the technologies, rather than through peer-reviewed academic papers. There is, therefore, a positivity bias in the kinds of sources which are published; organisations are less likely to publish case studies of technologies they have implemented which have not gone as planned (Fruchtman et al., n.d.). However, articles published by organisations overseeing or implementing the technologies still contain useful information and are supplemented in this paper by the academic literature that is available.

4. Part 1: Mobile Technology for the Health Supply Chain, Literature Review and 2017 Survey Results

Importance of Visible, Quality Data for the Health Supply Chain

Access to affordable, accessible, and acceptable quality medicines is one of the most crucial elements in implementing primary health care, especially in low- and middle-income countries. This is only possible through strong Health Supply Chains, a key part of which is visible, high-quality data available from the very start of a system right through to its end point. Such data is used to determine demand, plan procurement at the national level, monitor consumption trends, assess stock levels, decide on resupply quantities, prevent medicine expiry, and monitor the capacity and performance of the entire Supply Chain. Several studies show that data that does not flow freely within the Supply Chain results in stock outages of essential drugs and insufficient up-to-date information (Ramanujapuram and Akkihal, 2014; Ranck, 2011). Data collection is one of the most important elements of a public health system (Shao, Loconsole, and Hajinasabrazlighi,, 2012; Ranck, 2011). Data visibility brings several benefits to Health Supply Chains, including reducing stockouts, and when combined with strong data management also helps to reduce operational costs and improve the service provided (Fleming and Okebukola, 2020). In a 2017 PSA-implemented survey of over 100 Supply Chain professionals, 100% agreed that data on commodities is an essential part of the Supply Chain. Survey respondents also identified that the key datasets to collect in any Supply Chain were: stock-on-hand data, consumption data, and lead-time data, as well as wastages, expiries and patient data.

The importance of data in Supply Chain can be further understood through the following graphic from John Snow, Inc. (JSI), 2013.



Source: JSI (2013)

Figure 1 The role of data in Supply Chain evolution

The importance of data for the Health Supply Chain has attracted increasing attention in recent years. The United States Agency for International Development (USAID), one of the biggest donors in the Public Health Supply Chain, has recently worked on creating an integrated information system that combines three proven Information Technology (IT) solutions into a single, efficient portal. Other international organisations focusing on data for the Health Supply Chain include Kuehne and Nagel's Logistics Management Information System (LMIS) (used to target freight-forwarding operations), Chemonics' financial information management system (used globally to oversee government contracts and ensure compliance), and IBM's e-commerce suite (used around the world by some of the top Supply Chain operators) (Chemonics, 2016). Although these are expensive information systems that would likely be beyond the reach of the finances of many national governments, they clearly show that visible data is essential if Health Supply Chains are to operate effectively, and that many actors are beginning to recognise the value of different types of technologies for data visibility and integration.

The Challenge; Low Data Visibility in LMICs

In low-income countries, socioeconomic barriers, geographical factors, restricted information networks and low human capacity, especially in regard to management disciplines and technology usage, have hindered the availability of health data (Shao et al., 2012, Ramanujapuram and Akkihal 2014). This has affected data collection methods, which are often manual, paper-based and not standardised and therefore are difficult to process for analytical purposes and can cause inaccuracies (Mechael et al., 2010; Shao et al., 2012; Prosser, Sampath, Bancroft, and Wilcox, 2015; Utama et al., 2017).

The critical shortfall in health workers in low-income countries also affects efforts to improve the data collection and analysis processes. There are delays in reporting the collected data because of transfer costs, and transcription is required for electronic data entry and analysis once the data reaches the district or national level. This has led to the poor flow of health data, which hinders decision-making, and the fulfilment of the plans and policies that are created to improve health services (Asiimwe et al., 2012; Shao et al., 2012; Nyamtema, 2010). For example, Nigeria's health system previously included nine different Supply Chains and around 20 data systems, making supply management and decision-making on health commodity replenishment difficult (Fleming and Okebukola, 2020).

The number of different organisations working in low- and middle-income countries, including different donor-funded projects and government interventions, highlight the real and growing need for greater visibility and accountability in the health and humanitarian sectors. Many organisations have sought to address this challenge through the adoption of new technologies and computerised systems that increase visibility, provide data for better decision-making, and improve the efficiency of the Health Supply Chain.

Mobile Technology: Benefits and Possibilities

The magnitude of data required for routine and strategic decision-making is high and can be burdensome if it is not collected and analysed through appropriate forms of technology (Ranck 2011; Shao et al., 2012). Whilst paper-based techniques can be successful in collection, digital methods are a powerful gateway to data visibility (Fleming and Okebukola, 2020) as well as data analytics.

Whilst paper-based tools may be the only option in isolated or low-resource settings, steady improvements in information and communications technology (ICT) tools, such as computers, mobile devices, and the software that run on these devices, have dramatically expanded the options for collecting and managing Supply Chain data. These tools allow rapid and accurate data collection, which in many cases (especially in community data collection) are more practical, convenient and cost-effective. In addition, digitisation allows standardised data capturing, which improves data quality in many levels of the data collection process, including through standardised data collection forms, training for the platform used, easy creation of databases, reduced missing data, robust data (low standard deviation), and better analysis (Needham et al., 2009). These benefits of ICT have led to many pilot programmes and studies in electronic data collection, which have provided successful results (SIAPS, 2014; Asangansi et al., 2013; Ngoma et al., 2012; Kanjo, 2012), as illustrated in the nine cases in Part One.

Of all the ICT tools that exist for collecting data, mobile technologies are acknowledged as one of the most successful methods, with useful application in low- and middle-income countries where there is a rapid increase in mobile penetration, including in villages (Asangansi et al., 2013; Ranck 2011). Mobile devices additionally have been used for decades in enhancing Supply Chain Management generally and are now increasingly being applied to smaller health systems in LMICs (Roess, 2017). Mobile technologies ease the flow of health information, whether through simple voice calls, SMS (short message service) messaging or applications using wireless data, or mobile internet, and they provide accurate and rapid data collection (Ranck 2011). A further benefit of mobile technologies is in their ability to increase access through reducing geographic or low-resource barriers (de Morais, 2017). Mobile technology (alongside other technologies such as RFID (Radio-Frequency Identification) or blockchain) can also inhibit the global trade in fake medicines (Mackey and Nayyar, 2017).

Because of mobile technologies' strong potential to improve data collection in the Health Supply Chain in low and middle-income countries, research in mHealth has expanded, especially in early pilots. These pilots have successfully demonstrated mHealth's potential to increase access to healthcare, improve the ability to diagnose and treat diseases, expand access to health education and training for health workers, and specifically, strengthen the Health Supply Chain (Asangansi et al., 2013; Negandhi et al., 2016; World Health Organisation (WHO), 2011; Chib et al., 2012; Asangansi and Braa, 2010; Gold et al., 2012). For example, the United Nations Children's Fund's (UNICEF's) mobile-based Effective Vaccine Management system in the state of Bihar in India replaced the paper-based system of data collection in 2014. As a result, with better understanding of the needs of the state, cold storage space has increased from 49% in July 2014 to 87% in September 2015 (Negandhi et al., 2016). Also, mHealth allows *standardised* and *focused* data collection in a user-friendly and accessible manner. For example, sending simple weekly SMS messages to health facilities to update stock levels in Kenya's SMS for Life resulted in participation of 97% health facilities on average, which resulted in a reduction of stock-outs by 37% (SIAPS, 2014).

Mobile Technology: Challenges and Barriers

As illustrated above, mobile technologies show promise in supporting good quality data collection, greater visibility in the end-to-end Supply Chain from an enhanced information system, as well as analytics and decision-making abilities. However, the appropriateness of a mobile technology for each context must be thoroughly assessed before it is implemented. Systems are sometimes introduced in a rushed manner, with little consideration for the national context into which the technology is being introduced. There may not sufficient enabling infrastructure, and factors such as skills, language issues, internet access, and equipment availability are often not sufficiently accounted for (Asangansi et al. 2013), especially in LMICs.

Many information systems are donor-driven, creating sustainability issues: once funding ends, the system itself may collapse. In public health, the central government in a country must understand the sustainability of the electronic system before commissioning it for use. This includes an understanding of the long-term cost of the programme, including the cost of developing the system and annual recurring costs, as well as hardware, internet, mobile phone and training costs, and insurance. The decision to move to an Electronic Logistics Management Information System (eLMIS) from a paper-based LMIS should only be taken once the total annual cost of management is determined. It is also the responsibility of technical agencies and donors to work with national governments to achieve sustainability for the systems in place.

The collection of relevant data in Supply Chain also requires a significant human input, even where various technologies are present. In many Health Supply Chains in Africa, data collection methods are not standardised across programmes, and, hence, responsibility for collecting the data varies. Although the role of technology is crucial in the development of a seamless data collection strategy, it also heavily depends on the programme approach and the prevalent organisational culture (which is difficult to shift) in regard to collecting, transmitting and analysing data for decision-making. Whilst many users switch easily to digital systems, those with lower digital literacy may struggle to adapt or resist digitisation (Gilbert, Thakare, Ramanujapuram, and Akkihal, 2017). Countries must also invest in the data capabilities to support any changes (e.g. through developing data scientists or software developers) (Fleming and Okebukola, 2020). There can also be a tendency to report results as soon as possible, when there is little useful, clear information to transmit. This results in broken data integrity – a situation in which the systems often do not contain a complete or accurate record of inventory or supply movement transactions that have taken place (Ramanujapuram and Akkihal 2014).

One of the most critical barriers impeding mobile technology is a lack of integration. Whilst there have been many successful pilots of new technologies in the health sector, few programmes have managed to be successfully upscaled in LMICs, and often operate as stand-alone projects in a targeted population, rather than as an integrated part of the whole health system (Fruchtman et al., n.d.). Most pilots have not translated into widespread and scalable Digital Health Programmes (being project-based and externally funded) (Olu et al., 2019). Hence there has been an increasing shift towards integration and sustainability of programmes (Fruchtman et al., n.d.).

Moreover, as will be illustrated from the case studies in the following section, improving technologies on their own is not sufficient to create a strong Health Supply Chain. The use of mobile technology must be accompanied by other supporting factors such as sufficient human resources, leadership, good network access and monitoring of data quality (LeFevre et al., 2017). The work is not completed after the mobile solution is developed and implemented; it needs to be used by the staff at the health facilities and stores and should be of good quality. Ideally, this should be the responsibility of a centralised monitoring and evaluation team working alongside the Supply Chain department, which should analyse the data and then provide necessary support to the SDPs and the central office (Kiberu et al., 2014). However, the PSA 2017 survey indicated that only 5% respondents reported the existence of a monitoring and evaluation team to verify the accuracy and quality of data. In conjunction with the use of mobile technology to create good quality data, high quality data analytics should also be used to create accurate decision-making (Prosser et al., 2015). In summary, mobile technology is only one part of the Health Supply Chain and overall health system, and must be accompanied by other changes (such as strong governance, a well-trained and resourced staff and robust procurement strategies) to create long-term positive changes.

5. Part 2 – Case Studies

System 1: SMS for Life 1.0, Developed by Novartis Social Business and Roll Back Malaria Secretariat

SMS for Life was developed by Novartis Social Business division, in partnership with the Roll Back Malaria Initiative and other development partners in 2009. To create vendor choice, an additional software company, Greenmash, was contracted to develop a system with similar functionality (SMS for Life 1.0, 2017). The Vodafone version of the software was deployed in all public health facilities in Tanzania and the Greenmash version in all public health facilities in Cameroon. The solution was initially implemented for malaria commodities in Tanzania, where the pilot generated very good results. After the pilot in Tanzania, the solution has been deployed further in Tanzania and several other countries, such as Kenya, Ghana, Cameroon and the Democratic Republic of Congo. As of 2017, there were more than 10,000 users and the system primarily captured stock and disease surveillance data for the following products: anti-malarials, antibiotics, vaccines, HIV medicines, Tuberculosis (TB) medicines, leprosy medicines, blood supplies etc (SMS for Life 1.0, 2017).

Examples of Implementation

A primary cause of malaria deaths is continued stock-outs of effective antimalarial drugs caused by systemic shortcomings in countries (WHO, 2013). In 2009, Tanzania had the third largest population at risk of malaria and 11 million cases of malaria were occurring each year (WHO, 2009; Barrington, Wereko-Brobby, Ward, Mwafongo, and Kungulwe, 2010). At this time, the Supply Chain structure in Tanzania was mixed, with both *push* and *pull* mechanisms prevalent across districts. In some cases, products – artemisinin-based combination therapies (ACTs) and rapid diagnostic tests (RDTs) – were pushed to the health facilities every quarter by the district medical officer, based on requirement determined at the district. Alternatively, products were dispatched every month based on requisition from the facilities using the integrated logistics system (Barrington et al., 2010).

A 21-week pilot study, 'SMS for Life', was undertaken during 2009-2010 in three districts of rural Tanzania, involving 129 health facilities. At the start of the pilot project, 78% of the health facilities had no stock of one or more of the four different Artemether-lumefantrine dosage packs or quinine injectables. By the end of the pilot project, this proportion had fallen to 26%. On average, stock-outs showed a progressive decline throughout the project and stock levels increased in the facilities. Stock-counting data accuracy of 94% was achieved, and monitoring of data at the district levels was consistent (Barrington et al., 2010).

The Pilot project was then rolled out country-wide and was one of the earliest large-scale implementations of mHealth innovations globally, monitoring weekly stock levels of official first- and second-line anti-malarials in over 5,000 facilities. Whilst the initiative had positive effects, it was discontinued in 2015. The initiative did not have a final evaluation, though a non-peer reviewed study by Fruchtman et al. identified reasons for its discontinuation as perceptions of costliness by policy-makers, failure to adapt to the arrival of competitor systems in Tanzania, a focus on a single disease and a focus on stockouts rather than on ensuring appropriate stock management. However, the pilot itself was successful and the wider roll out of the programme helped to develop the country's capacity to accommodate and integrate further technologies into the health system (along with other technologies). Whereas previously ACT stockouts in mainland Tanzania were not well documented, SMS for Life 1.0 helped to produce real-time weekly stock reporting, helping to determine the frequency, magnitude, and distribution of stock-outs (Mikkelsen-Lopez et al., 2014).

Similarly, SMS for Life was piloted in Kenya to see whether visibility of stock at district levels could result in reduction of stock-outs (Githinji et al., 2013). Similar positive results were reported in Kenya, where stock levels gradually increased, with a reduction in stock-out situations. Furthermore, system adoption was positive, with stock data accurately reported (Githinji et al., 2013).

The respondent that PSA interviewed regarding mSupply highlighted several factors that can be beneficial in implementing SMS for Life 1.0 and mobile technologies: design a system that is simple from the end-user's perspective (with all technical issues and complexity transferred to the professional vendors), have an in-country presence with early discussion of funding, and find evidence-based solutions through publications and pilots. They further added that some form of incentive to use the system, an administrator at the Ministry with authority to take appropriate action and an in-country project resource are also required (SMS for Life 1.0, 2017).

Key factors for sustainability:

- SMS for Life is offered as a service – similar to Hotmail, Yahoo or Amazon – at a fixed cost, which allows exact total costs to always be known up front, simplifying grant requests (SMS for Life 1.0, 2017).
- All hardware and software are fully maintained and replaced every three years, at no additional cost (SMS for Life 1.0, 2017).
- Operated in a fully professional environment: Class A data centre, generator backup, multi-entry power and internet connections, full redundancy etc. (SMS for Life 1.0, 2017).

- Non-reliance on in-country technical staff (SMS for Life 1.0, 2017).

More broadly, the key to long-term sustainability lies with local ministries of health. They should commit at initial stages to taking over the system after successful roll-out, and to running it for an extended period until it is integrated into the mainstream health system and can continue to evolve in that context (WHO, 2013).

However, Fruchtman et al's study argued that the stand-alone nature of SMS for Life prevented information from flowing to other systems, which hindered the sustainability of the Programme (Fruchtman et al., n.d.). Fruchtman et al.'s study also highlighted that SMS for Life 1.0 was sometimes duplicative with other technologies in use. This highlights the importance of ensuring that any mobile technologies integrate with and do not duplicate new technologies introduced, and that initiatives which focus on more than one healthcare problem would create greater stakeholder engagement and hopefully more long-term viability.

System 2: SMS for Life 2.0, Developed by Novartis Social Business and Vodafone

The system for SMS for Life 2.0 was designed by a small team from Novartis, with support from the Nigerian Federal Ministry of Health. The software solution/system was developed by Mezzanine, a South African company majority-owned by Vodafone. Building on the original SMS for Life, SMS for Life 2.0 was launched in 2016. The system was first deployed in Kaduna State, Nigeria, with memoranda of understanding also signed for a Zambia deployment and other deployments directly implemented by Vodafone/Vodacom. As of 2017, there were approximately 300 users (SMS for Life 2.0, 2017).

The system builds on the original SMS for Life programme. In SMS for Life 2.0, the entire cycle is conducted through Android phone or tablet, using the SMS for Life intuitive application (app). The primary users of this app are the personnel at a health facility, for the collection of data, and the district supervisor and Ministry of Health, for monitoring, feedback and decision-making concerning the collected data. The data collected through SMS for Life 2.0 can be integrated with the country's health information system and strategy.

The system can track stock levels of various commodities, including anti-malarials, vaccines, and HIV, TB and leprosy treatments, and can send notifications to district medical officers when stock levels are low. The solution can also monitor surveillance parameters of malaria, maternal and infant deaths, and several diseases.

It allows ministries to deploy high-quality video and animated health worker training modules directly to a tablet at the health facility (SMS for Life 2.0, 2017).

Examples of Implementation

SMS for Life 2.0 was launched by Kaduna State in 2016 to enable healthcare workers to track stock levels of essential antimalarials, vaccines, HIV, TB and leprosy treatments and send notifications when stock levels are low (Novartis, 2016). It has also been implemented in Tanzania and Zambia to monitor a wide range of products at peripheral healthcare facilities. It uses updated technology and has an expanded range - to include vaccines and medicines for HIV, TB, and leprosy.

System 3: e-Vaccine Intelligence Network (eVIN), developed by Logistimo

eVIN is a mobile and web-based eLMIS which can be deployed at each level of the Supply Chain and can work with any type of health product (Logistimo, 2017). Based on the infrastructure, data can be collected offline on the software and once the device is connected to the internet, it is transmitted. Data can also be reported through SMS. It is designed to achieve highly reliable data collection and can scale with a large Supply Chain network (of thousands of nodes) and a high volume of transactions (many millions per day) (Logistimo, 2017).

It is an open source solution deployed across tens of thousands health facilities in India, in more than 2,000 facilities in Myanmar, and also in Zambia and the Democratic Republic of Congo. The system has been active since 2011. In India, the United Nations Development Programme helped with implementation and deployment of the system with funding from Gavi. In Myanmar, the system was deployed with the help of the United Nations Population Fund (UNFPA) and JSI. As of 2017, there were more than 12,000 users on the system (Logistimo, 2017).

Examples of Implementation

The system is operational in several countries. According to several studies and, in particular, a deep-dive assessment conducted by the Immunisation Technical Support Unit (ITSU) (Kapuria, 2015), there were severe issues in stock and data visibility and erratic distribution practices in India's Universal Immunisation Programmes (UIPs). Hence, eVIN was developed by ITSU. The model designed had to support the existing system of registers, develop the capacity of people working, have an easy interface, and be accessible for people with very few IT skills. Hence, Logistimo's software was selected by the government based on ITSU's developed terms of reference.

In 2015, in partnership with Gavi, the United Nations Development Programme (UNDP) supported the Government of India to launch the eVIN which uses smartphone technology to capture real-time data across the entire vaccine cold chain (UNDP, n.d.). This was conducted in 12 of 36 states and was rolled out further post-2017. It is now digitising vaccine stocks at all 27,000 vaccine storage centres across all districts of 29 states and 7 union territories of India. Amongst other tasks, in India eVIN is facilitating the real-time monitoring of storage temperature by installing nearly 50,000 temperature loggers (UNDP India, n.d.). It has achieved an over 80% reduction in vaccine stock-out instances and improved availability of stockout availability (ibid.). eVIN has helped create big data architecture and supports data-based decision-making and consumption planning. Vaccine availability has also increased to 99% in most health centres and instances of stock-outs have reduced by 80% (MHFW, 2020). A 2017 study of cold chain handlers at 29 Primary Health Centres where eVIN had been introduced, found that 86% were satisfied with the eVIN technology. Around one fifth had experienced difficulties in handling the smartphones, and one fifth had experienced trouble with the network connection (Kumar, Lohani, Kumar, Ahmad and Kumar, 2019). More recently, eVIN is being used by the government in India to monitor the Covid response Supply Chain with the potential to be leveraged for any new Covid 19 vaccine.

System 4: mSupply Mobile, by Sustainable Solutions

mSupply Mobile is a mobile app that provides an electronic medicine inventory. It can be used by rural health facilities even when there is no internet and will synchronise with a central mSupply server when the internet is available. It has been developed by Sustainable Solutions, and the mobile mSupply is an open source software. The mobile version of mSupply has been in operation since 2012. mSupply handles various tasks including issuing goods via the FEFO (First expiry, first out) principle, completing requisitions, tracking inventory, and managing tenders.

mSupply Mobile is designed to capture stock, inventory, procurement, issue and receipt, and patient data. Once these data sets are collected at the health facilities, the data is transmitted to the central server and thus other members in the hierarchy can also see the information on the dashboard.

Examples of Implementation

mSupply is used in more than 30 countries worldwide. It is used in most countries in the Pacific, as well as Timor-Leste, Myanmar, Laos and Cambodia (Tupaia, 2018). In Timor Leste, the government procurement team saved USD 1.3 million in 2016 using mSupply's tender module. In the Solomon Islands, medicine availability increased from 47% to >90% from 2007 to 2013 through a whole series of reforms supported by mSupply, including the first ever roll-out of mSupply Mobile. However, one study by the WHO examining the use of mSupply in Tuvalu found that one year after launch (2009), tender assessment and other features were not used fully due to issues with internet connectivity and staff knowledge of the system (WHO, 2010).

mSupply has recently partnered with Beyond Essential Systems (supported by the Australian Government Department of Foreign Affairs and Trade, DFAT) to launch the Indo-Pacific Health & Supply Chain Data & Technical Assistance Centre, aiming to improve access to essential medicines and support long-term health system development in the wider Indo-Pacific region. This will include the funded deployment of mSupply (Tupaia, 2020). The Centre aims to build a peer-to-peer network of local mSupply experts across the region and create a 'Health Supply Hub' which allows countries to post tenders, receive bids and manage quality assurance documentation.

The respondents that PSA interviewed regarding mSupply highlighted that user commitment to the system is vital to produce results, and that there should also be management oversight to ensure users are engaged, committed, trained, and supported. They also emphasised that training on the system should be conducted before initiation and after any major upgrade to the system, that the quality of hardware should be good, and that adequate technical or internet outreach in the country is critical (mSupply, 2017).

System 5: CommCare Supply, developed by Dimagi

CommCare Supply is an open source SMS based system deployed widely within the health sector generally and whose users are often frontline workers, such as community health workers. It can be used specifically within the Supply Chain sector to strengthen logistics management and supports health workers and other mobile agents who manage commodities in low-resource settings. It has been proven at scale, through real-world deployments, to provide reliable, real-time, and actionable information to improve the performance of new and existing Supply Chains.

CommCare is designed to capture stock data, logistics data, consumption data, payment tracking, reporting rates, coverage ratio, and user activity, among other data sets (CommCare Supply, 2017). CommCare Supply began with providing SMS solutions, enabling any functional mobile phone to submit a stock report and receive corresponding alerts and reports in structured SMS format. A mobile app and a web version that helps supervisors work with the persons in charge of health facilities have also been created. The app can be used offline and the data synchronises once the device is connected to the internet. (CommCare Supply, 2017).

System based on CommCare by Dimagi: Early Warning System: Ghana, developed by JSI Research &Technology, USAID DELIVER and Dimagi

Early Warning System (EWS) is an SMS-based stock-reporting system which was developed in 2009 by JSI under the USAID DELIVER project, with the support of Dimagi. It started its operations in Ghana in July 2011. The system was specifically designed for reproductive health commodities to enable decision-makers to see the real-time stock status information, and to provide a warning when they see a dip in stock. Another objective for the system was effective supervision during ordering, leading to better availability of commodities and reduction in emergency orders (Dimagi, 2015a).

Example of Implementation

The original pilot for EWS was conducted in 2011 in 201 facilities across all 10 regions in Ghana, with 88 USAID Focus Region Health Project (FRHP)-supported sites and 113 USAID DELIVER PROJECT-supported sites. Users were asked to report on 43 tracer commodities within malaria, HIV, and family planning commodity classes (Kamunyori and Getachew 2013).The system operated through staff at health facilities sending weekly text messages from their own mobile phones to report the stock levels of a subset of their managed commodities (tracer commodities). The reported information was then compiled and displayed on a web-based dashboard that provides reports related to stock availability and reporting rates, allowing decision-makers at the higher levels of the Supply Chain to understand the information and make decisions regarding resupply. Data was processed in such a way as to show the national aggregate data and also the region/district/facility-wise data if drilled down.

An assessment was conducted in 2012 under the DELIVER project to understand the adoption and impact of the system. It reported that EWS was able to improve the data visibility of Supply Chain data. However, it also observed that not all the decision-makers were using the system. Given the generally positive results from EWS, it was decided to scale up the operations of EWS and also to include Anti-Retroviral Therapy (ART) sites. A further assessment in 2013 showed that the system provided real-time data on stock status, which guided decisions and improved recordkeeping in facilities (USAID, 2016). As of early 2016, the EWS was operating in 700 facilities, including the Central Medical Stores, three teaching hospitals, district hospitals and others (ibid.)

A respondent that PSA interviewed regarding CommCare highlighted critical factors to overcoming challenges and increasing the chances of the project's success. This includes the client setting aside enough budget to finance the technology long-term (including CommCare subscription, phone purchasing and user training), incentivising users to use the app, purchasing durable and high-quality phones and training users to use them. They further highlighted that any app should reduce, rather than increase, the workload and that the client should reach a stage where they can train new users and navigate the web platform without assistance from the implementer. This correlated with a study conducting a meta-analysis of 64 different projects using CommCare, which highlighted the importance of humanitarian projects emphasising worker training and monitoring in their deployment of mobile technologies (Dayalu, Wacksman, Chen, Loudon and Lesh, 2015). The respondent further stated that it is important to assess the technical capacity of country teams, and if a team needs capacity building in computer skills, or on using a smartphone, the project implementation and training will take longer, which affects the timeline for deployment (CommCare Supply, 2017).

System 6: RapidSMS

RapidSMS is a toolset for rapidly building SMS-based data collection systems. RapidSMS was initially created by UNICEF's Innovation Unit in 2007 to support UNICEF's data collection and youth engagement activities. RapidSMS was initially designed to be customisable to meet the challenges faced by various organisations, including governments and development practitioners, and to work effectively despite geographical challenges, poor infrastructure and slow, often paper-based data collection (Rapid SMS, n.d.). RapidSMS has been customised and implemented with diverse functionalities in several sectors including public health and Supply Chain.

Systems based on RapidSMS:

1. ILS Gateway

ILS Gateway is an open source solution, built on RapidSMS, which allows health facility personnel to use personal mobile phones to send SMS messages to a toll-free number as short-code report data on stock levels. The mobile-based solution was implemented by JSI, with Dimagi (on RapidSMS code) and the Tanzania Ministry of Health and Social Welfare in 2008, with funding from the USAID DELIVER Project to support Tanzania's Integrated Logistics System (ILS). The objectives of the ILS Gateway were to provide real-time stock status information on selected health commodities; improve the timeliness and accuracy of paper-based ordering and reporting from the SDPs; strengthen the accuracy and timeliness of deliveries to SDPs by confirming delivery arrival in real-time; and facilitate the ability of decision-makers at all levels to monitor the regularity and spread of facility-level supervision in Tanzania (Dimagi, 2013; USAID, 2012).

Example of Intervention

ILS Gateway did not replace the paper-based reporting system in Tanzania, it provided visibility into monthly stock levels based on the SMS reporting. In addition to tracking and reporting on end-of-month stock-on-hand, ILS Gateway was also designed to reinforce and monitor the ILS, which is used to order and distribute the majority of medicines and supplies for health facilities in Tanzania. The key system data points are stock-on-hand, losses and adjustments, submission of R&R data, and receipt of orders. The following graphic provides a visual summary of the operational framework for ILS Gateway in 2011 (USAID, 2011):

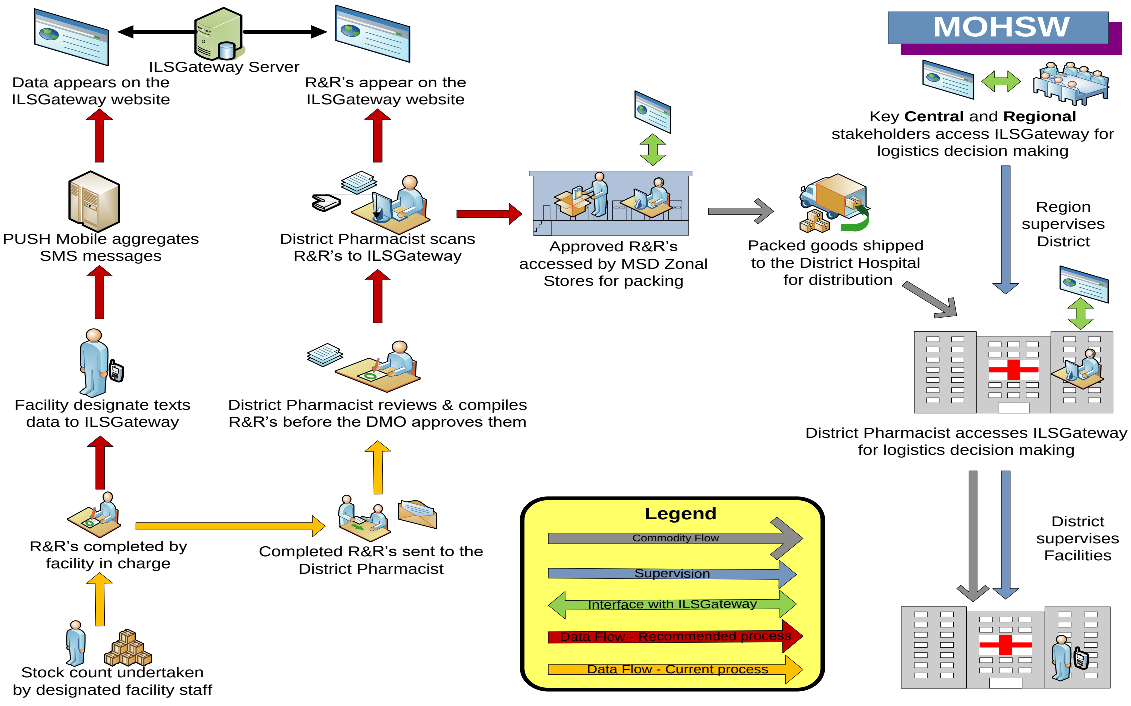


Figure 2 Operational Framework for ILS Gateway in 2011 (USAID, 2011)

The pilot project conducted a qualitative and quantitative review workshop, attended by users from various facility, district, and central levels, to evaluate the system's functionality and impact. During the workshop, the majority of the respondents reported that ILS Gateway improved their diligence in conducting stock counts on time, that the system has improved their ability to submit the reports to the districts on time, and that it has increased product availability and reduced lead times (USAID, 2012).

2. cStock: Malawi, developed by SC4CCM (JSI) and Dimagi

In Malawi, community health workers, also known as Health Surveillance Assistants (HSAs), provide community case management (CCM). These HSAs carry and prescribe a defined list of essential medicines, such as oral rehydration solution, anti-malarials, antibiotics, and family planning commodities. This project was implemented by JSI Research and Technology, with funding from the Bill and Melinda Gates Foundation. The solution, a fully customised version of RapidSMS, was developed by Dimagi. The solution allows the HSAs to use their personal phones to submit stock information via SMS, allowing community-level data that was previously unavailable to be visible to decision-makers at all levels of the system (Dimagi, 2015b).

Example of Intervention

The solution was developed to address the needs identified in the country related to poor availability and limited use of logistics data, which was leading to low product availability and low morale of community workers. Due to the low visibility of data, the community workers were reluctant to travel to the stores to collect products as the products might not be available, as well as long travel times and difficult terrain in the country. Hence, cStock was deployed to improve data visibility across all levels and reduce stock-outs of products, thus boosting the motivation of community workers (Shieshia et al., 2014; SC4CCM Project Team, 2014).

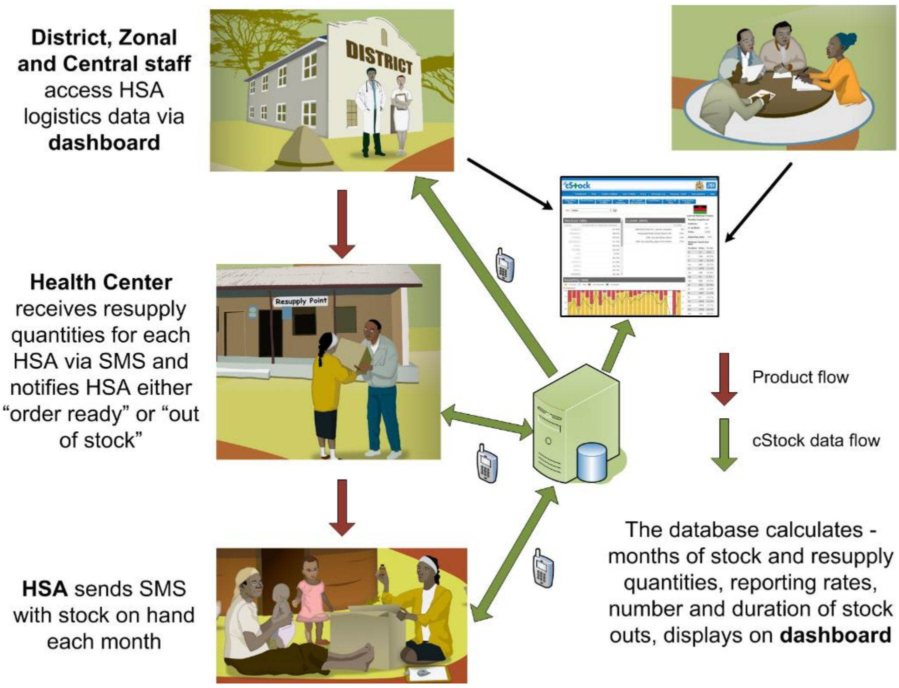


Figure 3 cStock Data and Product Flow (SC4CCM Project Team, 2014)

Key features of the cStock system included: automatic calculation of the resupply needs for an individual, based on reported stock levels and system-calculated consumption, and alerting staff if supplies cannot be replenished. cStock also made data available via a web-based dashboard that provided timely visibility into actual stock levels held by HSAs, enabling real-time identification of problem areas and overall monitoring of Supply Chain performance by the district and central-level administration. HSAs are also informed not to travel until they have received an order ready message (Dimagi, 2015b; SC4CCM Project Team, 2014).

cStock was not designed to replace the paper-based LMIS procedures but to fast-track the ordering process. The original paper-based process of resupply was faced with several challenges, which resulted in delays in resupply (Dimagi, 2015b).

The reporting rates of the data in the districts where cStock was deployed were above 80% on average, with some districts reaching 100%. There was a good acceptance level by personnel of cStock and a study reported that over 90% of health workers are comfortable with the system and are using the system as the primary means of data collection and reporting. The system has also resulted in better availability of products and reduced lead times for resupply (Shieshia et al., 2014; Dimagi, 2015b).

System 7: DHIS2

Since 2017, InSupply Health, JSI and the Government of Kenya have been implementing the cStock approach in Kenya to improve the Supply Chain for Community Health Volunteers (CHVs) and last mile commodities. This builds on the approach in Malawi, although it uses DHIS2 – a widely used HMIS programme – to help with the intervention's scalability and sustainability. In Kenya, the cStock approach uses a combination of three elements: mobile technology, a user-friendly dashboard to enhance end-to-end visibility, and impact teams to strengthen data use (InSupply Health, 2020).

DHIS2 is widely used (over 60 countries as of 2018) and in a growing number of community health programs. The software is flexible, open source and specifically designed to support Health Management Information Systems (HMIS). DHIS1 is often used as a national HMIS system for routine data management and includes features such as Geographic Information System (GIS) mapping for high-quality data visualisation (UN, 2017). It is interoperable with CommCare at the mobile level.

Example of Intervention

InSupply Health successfully piloted cStock in two sub-counties in Siaya county in Kenya, before undertaking an intensive Human Centered Design (HCD) process to enable cStock to be scalable across all 47 counties. Building on the initial success of the pilot, cStock has been scaled up to the whole of Siaya Country and rolled out in 4 counties in Northern Kenya: Turkana, Samburu, Mandera and Wajit. As of 2020, 241 Community Health Assistants (CHAs) and 3,527 CHVs have been trained on the cStock approach and inSupply Health is working with Kenya's MoH to support cStock being scaled up across the whole country. 94% of CHVs noted that they found it easy to use the cStock platform and have incorporated the cSTock tools in their practices (InSupply Health, 2020).

System 8: mBrana

mBrana is an electronic logistics management system used in Ethiopia that is available in both mobile and web forms. It provides a vaccine commodity inventory management system for Ethiopia's districts. It was developed and deployed in partnership between the Ethiopia Pharmaceutical Supply Agency (EPSA) and JSI in 2015, as part of EPSA's vaccine Supply Chain transformation and in response to connectivity related challenges woredas (districts) were facing in using EPSA's Health Commodity Management Information System (HCMIS).

mBrana has interoperability with other upstream logistics tools, including EPSA's Management Information System, allowing automatic ordering and also the syncing of data to the national FANOS Supply Chain Dashboard, enhancing data visibility of district stock and of what is used at facilities. mBrana has its own dashboard with summary data for woredas, with dashboards tracked monthly to identify challenges. The open source system was developed locally.

As of early 2019, the system has been deployed to nearly 700 woredas, providing data visibility and electronic ordering in real time (JSI, 2019).

Example Implementation

The mobile platform is cheaper and easier to use, and has improved user acceptability, when compared to a desktop or internet-based system (JSI, 2017). Whilst baseline data was not available, district level vaccine stock availability reached 89.6% by September 2017 (JSI, 2017). The system increases efficiency by reducing the reporting time from up to five days to just minutes and reducing other related costs such as fuel etc.

Some challenges remain in terms of data quality, in particular with data use. Existing processes often do not account for the availability of real time data, such as vaccine forecasting, which is still mainly based on target and population data and not on logistics or consumption data (JSI, 2019). However, the Federal Ministry of Health is working to expand the culture of data use within the Ethiopian health sector. Future priorities for mBrana include increasing facility level data visibility, data quality and the use of data for improved Supply Chain performance.

System 9: MedPRO

MedPRO (Medicines Pricing, Reporting and Order Management) is a mobile app addressing last mile health supply challenges. The app is proprietary to PSA and was created as part of PSA's technical assistance to the Public Health Supply Chain in Niger state in Nigeria, funded by the Bill & Melinda Gates Foundation.

MedPRO addresses last mile challenges through focusing on the following three areas:

- **Unified pricing**: enabling the Drug Management Agency (DMA) to set uniform retail prices for commodities across all the facilities.
- **Reporting**: real time reporting and visibility of logistics data across all facilities
- **Order Management**: offering a seamless and faster order processing turnaround time and the ability to track the status of orders in real time.

For ordering commodities, users can select the medicine they require, then select and review the quantity they require and order it through the app. Once completed, the user can check the status of their order via MedPRO, and the Central Medical Stores can view the order details. To support health facilities with reporting, users can view and amend their facility's stock details. This information is then viewable by the central DMA. For commodity pricing, MedPRO provides a commodity price list that can be viewed at the user's convenience.

Example of Implementation

MedPro has been piloted in six health facilities in Niger State in 2020. It is currently awaiting full scale deployment in these states, with the long-term aim of expansion to other Nigerian states and then internationally. The app was introduced to overcome various problems health facilities were facing in Niger State, for example, there are numerous health facilities in Niger State that sell the same commodities at different prices. The unified price feature of the app helps users to ascertain a standardised selling price. Before MedPro was introduced, health facilities placed requests for commodities either by emailing a spreadsheet, or by taking a physical document to the Drug Management Authority in the state capital. MedPro allows health facilities to make requisitions via an app, avoiding the need to travel or send emails. This reduces the lead time and increases the accuracy of orders. Similarly, prior to the implementation of MedPro, health facilities would submit their stock status reports either by emailing spreadsheets or by a physical copy brought to the DMA. The app provides a way to conduct reporting without needing to spend time or resources on compiling emails or travelling to the state capital.

The implementation of the app is still in very early stages so lessons learned and recommendations are not available at this stage.

6. Discussion and Shared Learnings

This study has highlighted the key benefits that mobile technology programmes can bring to the Health Supply Chain. This includes decreasing stockouts (e.g. eVIN achieved an 80% reduction in stockout instances in India) and increasing medicine availability (e.g. medicines availability increased from 47% to >90% from 2007 – 2012 with mSupply). Mobile technology has helped with consistent data monitoring (e.g. SMS for Life 1.0 pilot in Tanzania) and the creation of big data architecture (e.g. it has allowed decision-makers to understand information at the facility level and make decisions accordingly.) Mobile technology has provided visibility on stock levels and reporting on stock-on-hand, reinforcing existing paper or computer based systems, improved staff diligence of submitting reports on time (e.g. ILS Gateway in Tanzania) and automatically calculating resupply needs based on reported stock levels and calculated consumption (cStock in Malawi).

However, several of the pilot studies included in this report were either discontinued or did not achieve their full objectives. Reasons for this include costliness, a focus on a single disease (e.g. SMS for Life 1.0) or a focus on a single issue (such as stockouts rather than the broader root cause of stock management problems). Difficulties in using the technology or poor staff knowledge of the system were other barriers listed. A lack of use is another issue, and an assessment of the EWS in Ghana found that not all decision makers were using the system.

External factors, such as network connectivity and other infrastructural concerns, are also a key reason for the failure of mobile technology programmes. In an implementation of mSupply, connectivity was one reason why procurement remained an issue one year after the system was launched (WHO; 2010). As mentioned in the case of mBrana in Ethiopia, existing processes do not always account for the availability of data, though this is being addressed by expanding the culture of data use in the Ethiopian health sector. If there are key external factors negatively impacting the flow of health commodities along the Supply Chain, a mobile app alone cannot fix these.

Recommendations for successful implementation of mobile technology, based on the case studies in this report include:

Training: This is crucial as there may be several health workers who have not used mobile phones or computers for any kind of data collection activity. Ideally, training should be included within the initial development and deployment phase. Further refresher trainings should also be organised.

Cost of solution and sustainability: The country partner, in discussion with donor agencies and technical partners, should decide how the solution will be operated in the long run. Based on this decision, the cost structure of the solution can be finalised. For example, if the government intends to support the solution after its development and initial deployment phase, then the recurring costs need to be very low for the government to be able to meet it. However, sometimes the donors purchase a solution for a specified number of years (e.g. five years), where the initial cost is relatively lower, with relatively high recurring costs. The presence of an in-country based project resource for Supply Chain strengthening is also important.

Adequate human resources: Human resources are the essence of any programme implementation and mobile data collection is no different. There should always be sufficient human resources to monitor the solution and provide support to the personnel on the ground using the solution. Public health systems data entry is often performed by medical staff, such as pharmacists and nurses. Such staff are often overwhelmed with their patient workload and data entry is something that frequently has to be de-prioritised. There needs to be a realistic consideration of whether staff will be able to enter data into the new system and what will motivate them to do so. Alternatively, additional staff need to be allocated to the health facilities to manage the data collection process. Furthermore, there should be a centralised monitoring and evaluation team working alongside the Supply Chain department to verify the accuracy and quality of data, monitor and analyse the data and provide necessary support to the SDPs and the central office.

Leadership and governance: The solution must be supported by the leadership in the country (preferably the Ministry of Health) and regular evaluation of the system should be conducted. The leadership should be involved in the advocacy of the solution to encourage the personnel on the ground adopt the new mechanism of data collection. Also, local ministries of health should be involved and commit at initial stages to take ownership over the system after successful roll-out and to running it for an extended period, until it is integrated into the mainstream health system and can continue to evolve in that context.

Consider in-country infrastructure: It is important to have viable telecoms infrastructure in the country which can provide low-cost SMS or data packages to the government for the mobile solution. This should be economically viable for the telecoms provider as well. Without this, the solution will eventually fail. Having an operational paper or web-based LMIS also helps in implementing mobile technology, as on-the-ground personnel already understand the importance of data collection and have experience in this area.

Technical specifications of app: Any app should be user-friendly and easy to use. Open source solutions are useful, as these can be modified and expanded later, without substantial costs. Proprietary solutions mean working with the same service provider throughout the life cycle of the solution. An SMS-based solution can be used on any phone, whereas app-based solutions will require more advanced phones. It is important to see whether the app runs on a JAVA platform, Android OS or iOS. The cost of the phone thus will vary as Java-based GPRS-run phones tend to be much cheaper than Android OS and iOS phones. Purchasing high-quality, durable phones for users to use is also beneficial.

User engagement: Any mobile technology should reduce, rather than increase, staff workload. Incentives to encourage staff to use the app can also be beneficial. User commitment to the system is vital to produce results.

Type of data collected: The mobile solution should, at a minimum, be able to collect the stock data and the consumption data at the last mile, and stock data and issue data at the penultimate store in the Supply Chain. It is important to have a central dashboard where the analysed data is shown to the decision makers. The dashboard should be based on key performance indicators from the Supply Chain, like stock-out rates, product availability, replenishment response time etc. Furthermore, the central office should also have some kind of bulletin board where the activities of all the users can be tracked.

Not be siloed: Any new technology should integrate, with and not duplicate, existing technologies, information systems and the overall health systems. It should have interoperability with other upstream logistics tools. It can be beneficial if the mobile technology engages with more than one health produce, rather than adopting a very narrow focus.

7. Conclusion

Data is the fundamental building block for managing any Supply Chain. Data, such as stock-on-hand and consumption data at the last mile, is essential to planning and operating a health Supply Chain. Paper or spreadsheet-based systems are slow and have a high rate of errors. Many of the technology solutions described in this study are constructed in such a way as to reduce data entry errors. Furthermore, once the data has been entered in an electronic system, it does not have to be re-entered, which further reduces the opportunities for errors.

An electronic data system that makes use of mobile technology for data capture eases the data entry process, and when used successfully, provides visibility of every point in the Supply Chain. This ensures processes, such as invoicing and ordering from suppliers, are much faster and more accurate than paper/spreadsheet-based systems. Furthermore, systems with better visibility lead to improved monitoring and management.

A booming mobile technology industry has led to the development of several mobile technology products for data collection, and prevalence of mobile technologies is quickly growing in LMICs. Mobile technologies therefore offer key opportunities to Health Supply Chains in LMICs, and the case studies in this report have shown how mobile technology can decrease stockouts, help with data monitoring, aid-decision making and improve timely reporting in this context.

Whilst opportunities offered by mobile technologies are great, there are also key obstacles. Clear success has been achieved with pilot studies or focused interventions, though these often do not scale up to broad, country-wide or international programmes. There must be mobile/telecoms infrastructure in place in the country for mobile technology to succeed, with adequate attention paid to each region's context before deploying a mobile technology. Sufficient human resources and the good management of data once collected are also essential.

As shown in the case of Malawi's cStock, to make mobile technologies for Health Supply Chain scalable and country-owned, it is important to establish multi-level quality improvement teams to help health surveillance workers to connect with decision-makers at higher levels of the health system, align objectives, clarify roles and promote trust and collaboration.

Most critically, any new technologies should be integrated with existing technologies and the existing health system, rather than operating in a siloed manner. Whilst mobile technologies have been shown to improve data collection in the Health Supply Chain, implementing such technologies on their own will not result in a strong Health Supply Chain: all of the other elements must be strengthened too.

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