The Role of Information Technology in Public Health Supply Chains: Current Challenges and Future Opportunities

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A Literature Review
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Executive Summary

This paper is the first in a series focusing on the successful implementation of Information Technology (IT) to public health supply chains in developing countries.

There are currently numerous aid organisations working in developing countries, all funded by different donors. As such, there is a real, and growing, need for greater visibility and accountability in the health and humanitarian sectors. One way many organisations have sought to address such a challenge is 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.

Many systems have, however, been introduced in silo, and their impact has been mixed, due to sustainability issues, rushed implementation, and a lack of enabling infrastructure, among other causes. The systems cannot therefore be relied on to present an accurate picture of an organisation's current reality.

Given the huge costs involved in systems development and implementation and the need to save money so as to reach as many beneficiaries as possible, donors undoubtedly need to rethink their investment systems. The questions then become: what are the most effective systems that can be put in place, and how can they best be implemented in a coordinated manner?

The literature review in this paper outlines the current challenges facing public health supply chains, highlights the potential that exists for IT to address many of these by referencing numerous positive case study examples, and addresses some of the barriers to introducing IT in public health supply chains, offering suggestions on how these may be overcome. Several problems feature in the literature, including a lack of coordination, uncertainties in financing and diffuse accountability; but what can be recognised is that poor IT, or a complete lack of it, is often behind many of the issues recognised in public health supply chains.

The paper concludes by observing that there is a great deal that national governments looking to strengthen public health supply chains can learn, not only from the private sector, but also other sectors in which technology is widely used. This will save time and money and lead to improved supply chains for those who most need care.

Introduction

This paper is the first in a series focusing on the successful implementation of Information Technology (IT) to public health supply chains in developing countries. It follows PSA's 2015 White Paper 'Humanitarian supply chain information systems: insights for successful implementation', a piece of work commissioned by the Médecins Sans Frontières' Operational Centre in Amsterdam that involved conducting a benchmarking survey of similar international humanitarian organisations which had implemented, or were planning to implement, a supply chain management system in the field.

There are currently numerous aid organisations working in developing countries, all funded by different donors. As such, there is a real, and growing, need for greater visibility and accountability in the health and humanitarian sectors. One way many organisations have sought to address such a challenge is 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.

Many systems have, however, been introduced in silo, and their impact has been mixed. The majority of information systems are donor-driven, which presents sustainability issues: once funding ends, the system itself may collapse. Further, some systems have been introduced in a rushed manner with little consideration for the national context into which such technology is being introduced. There may be little enabling infrastructure, and factors such as skills, language issues, Internet access, and equipment availability are little accounted for. There is also a tendency to try and report results as soon as possible when there is little useful, clear information to transmit. There is often also inconsistent use of the systems due to high turnover in the field. This results in broken data integrity – a situation where the systems often do not contain a complete or accurate record of inventory or supply movement transactions that have actually taken place. The systems cannot therefore be relied on to present an accurate picture of an organisation's current reality.

Technologies that have been introduced with mixed results into public health supply chains in the developing context include Dedicated Logistics Systems; Humanitarian Logistics Software; Health Administration and Management Systems; Radio Frequency Identification (RFID); SMS for Life; Logistics Management Information Systems (LMIS); and CommCare. Some of these will be touched on in greater depth later in the paper.

Given the huge costs involved in systems development and implementation and the need to save money so as to reach as many beneficiaries as possible, donors undoubtedly need to rethink their investment systems. The questions then become: what are the most effective systems that can be put in place, and how can they best be implemented in a coordinated manner?

Literature Review

Underpinning a strong national health system is a supply chain that can guarantee the consistent availability of affordable, high-quality vaccines, drugs and health products at all health service delivery points (Foster et al., 2006; Seiter, 2010; Frost et al., 2011). Not only do they deliver health products and medicines to the population, but they also return crucial information regarding demand, need and consumption to national health system planners (Yadav, 2015). As such, the strength of supply chains determines the overall health system's ability to respond to the health needs of the population and affects the success of national treatment programmes.

However, supply chains which serve the populations of many low-income countries are vast, disintegrated networks of players and products, loosely held together by manual and people-intensive processes (Langabeer, 2005). As supplies move down the supply chain towards hospitals and other health facilities, the robustness and quality of accompanying information and management systems used to manage these products significantly deteriorates (Matthew et al., 2013). In such a context, managing flows of information, equipment, services and supplies from the point of manufacture to the point of distribution to the point of care provision is particularly challenging when compared with more technology-intense industries such as industrial manufacturing or consumer goods (Langabeer, 2005).

Public health supply chains have recently come under mounting pressure to operate more efficiently (JSI, 2012; Matthew et al., 2013). Supply chains need to have the capacity and flexibility to adapt to large-scale investments in health programmes, a growing portfolio and volume of health products, and the expansion of services to new populations. At the same time, policymakers and donors seek accountability from each component of the supply chain and enhancements that can be sustained without indefinite funding (JSI, 2012) (see Figure 1).

New, ever-affordable technologies have the capacity to connect people and can assist countries in strengthening their health supply chains in this increasingly complex environment. The availability of information is crucial if processes of planning, distribution and monitoring are to be made more efficient (Riungu, 2011) and if costs are to be reduced (Matthew et al., 2013). It is thus essential that the potential of devices and systems such as mobile phones, electronic tools, data processors and even drones are explored, and lessons are learnt from other national contests or industries that have already had access to new and innovative technologies.

Figure 1: Changes in the Supply Chain

Source: JSI (2012)

This review of the literature outlines the current challenges facing public health supply chains, highlights the potential that exists for IT to address many of these by referencing numerous positive case study examples, and addresses some of the barriers to introducing IT in public health supply chains, offering suggestions on how these may be overcome.

Challenges in Public Health Supply Chains

Although this paper is not an in-depth analysis of the numerous problems that persist in the public health supply chains of many low-income countries, it is useful to touch on the body of work which addresses such issues as providing a useful context for assessing the current role of IT in health supply chains, and where technology has the capacity to improve the situation. Several problems feature in the literature, including a lack of coordination, uncertainties in financing and diffuse accountability; but what can be recognised is that poor IT, or a complete lack of it, is often behind many of the issues recognised in public health supply chains.

The issue of a lack of supply chain planning data features in much of the literature, Currently, in the majority of countries, there are no processes in place through

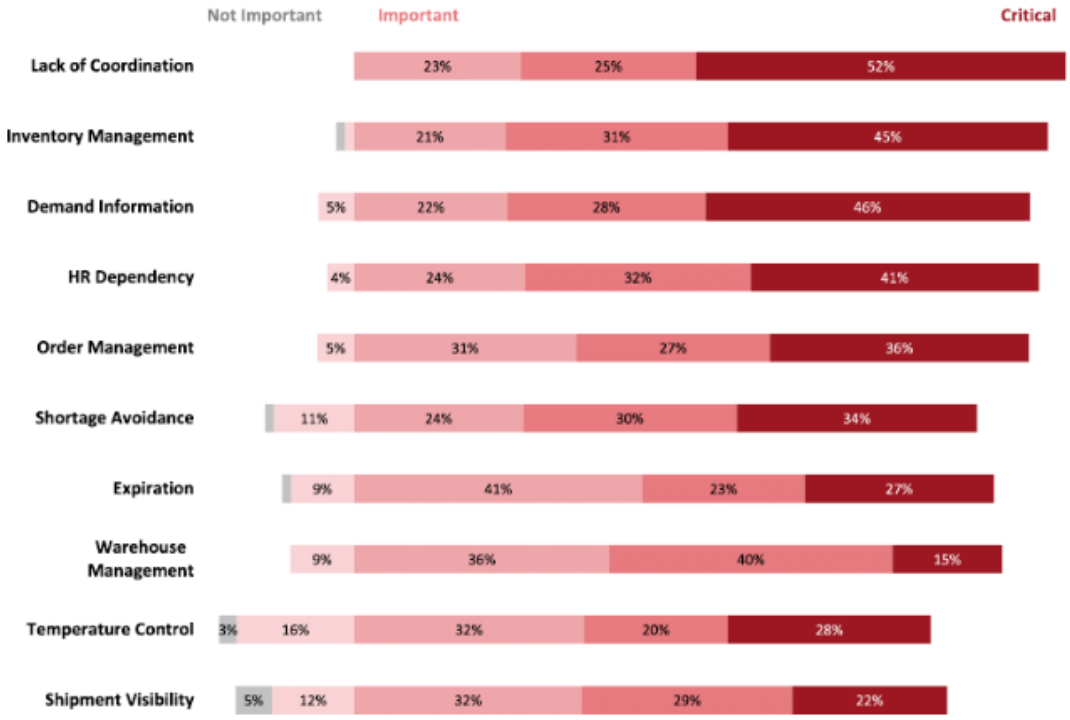
which information about consumption can be systematically captured (Sarley et al., 2009). In many cases, information on stockouts is gathered through *ad hoc* surveys that do not have the capacity to provide the continuous information feedback required for supply chain planning (Yadav, 2015). In the absence of regular stock and consumption information, public health supply chain planning tends to be conducted based on estimates drawn from outdated assumptions (Sarley et al., 2009).

Public health supply chains are also said to contain, or create, unnecessary levels of uncertainty. The structure of health supply chains in many developing countries is mapped to the administrative structure of the country, leading to multiple tiers of stock holding and stock allocation decision-making in the supply chain (Yadav, 2015). Aside from creating a lack of accountability, having several tiers in a supply chain, along with weak and less frequent communication between tiers, contributes to a phenomenon called "the bullwhip effect", creating increasing swings in inventory response to shifts in customer demand the further up the supply chain you go (Lee et al., 1997). Small variations in patient demand at the health clinic level are amplified as order information flows upstream, meaning the different tiers in a supply chain can get "out of sync" with actual demand, thus increasing the risk of stockouts (Cachon et al., 2007).

Uncertainty in financing is a further problem in public health supply chains. The long procurement cycle through which government purchasing is conducted can be initiated only when funds are disbursed from the Ministry of Finance or donor agency to the Ministry of Health or procuring agency (Yadav, 2015). The timing of the disbursement of such funds is uncertain and highly variable, resulting in delays to the start of the procurement cycle (Natarajan and Swaminathan, 2012) as well as the turnover of trained and knowledgeable staff seeking a longer financial commitment elsewhere.

Privett and Gonsalvez (2014) identify 10 supply chain issues affecting the pharmaceutical industry (see Figure 2), many of which also apply to public health supply chains in general. They include inventory management, order management and expiration, all of which can be blamed, in part, on poor, or inappropriate, IT. The issues regarding order management, for example, are directly tied to a lack of reliable demand information and shipment visibility. As a result, it tends not to be known if there is enough of a product in the system or at the Central Medical Store (CMS), and planning and ordering are often based on experience and assumptions due to this lack of reliable data (*ibid*). Inventory management was also considered a critical problem by 45% of survey participants and can be blamed on inventory inaccuracies, poor product availability management and inappropriate IT systems (Privett and Gonsalvez, 2014).

Figure 2: Top 10 global health pharmaceutical supply chain issues rating



Source: Privett and Gonsalvez (2014)

According to Yadav (2015), the lack of a structure of accountability underlies many public health supply chain issues, and there tends to be fragmentation of governance and responsibility between health professionals in clinics and at the district level, the CMS, and the Ministry of Health (MOH). For instance, in countries such as Mozambique and Kenya, the CMS only retains direct control over its own warehouses and distribution up to the district/region level, whereas all sub-national entities in the health supply chain are under the control of other departments in the MOH (*ibid*). This creates a system of diffuse accountability whereby each actor or stage in the supply chain can "pass the buck" for failures to other actors in the system with little means of tracing the root cause. Such an overall lack of accountability heightens the risk of corruption at the procurement and distribution stages (Vian, 2008; Bateman, 2013).

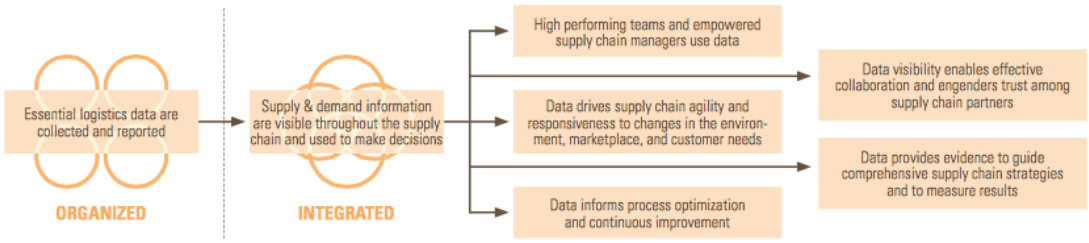
The Opportunity

Due to the vertical internal structures of organisations involved in public health supply chains, it tends to be the case that products and data regarding stock levels have been siloed and firewalled, resulting in the fragmentation of information of importance to efficient business operations (Kiewiet, 2015). Healthcare organisations often find it difficult to access supply chain data to establish actionable steps to increase efficiency, and this can lead to millions in wasteful spending (Belliveau, 2017). In response to public health supply chain problems, and in an effort to improve performance, many scholars and organisations have

recognised that information sharing is crucial, and that the key to this is harnessing available IT (Frost et al., 2011; Riungu, 2011; Belliveau, 2017).

The hallmark of an agile, well-integrated public health supply chain is the visibility of high quality data from the very start of a system right through to its end point. Such data is used to determine demand, to plan procurement at the national level, to monitor consumption trends, to assess stock levels, to decide on resupply quantities, to prevent produce expiry, and to monitor the capacity and performance of the supply chain as a whole (JSI, 2013). Clearly, an abundance of data is required for routine and strategic decision-making, and this can be burdensome if not collected and analysed through various forms of technology. Automation ensures more streamlined and timely data management, analysis, action and visibility (*ibid*) (see Figure 3).

Figure 3: The Role of Data in Supply Chain Evolution



Source: JSI (2013)

A focus on data visibility is central to the USAID Health Supply Chain, andUSAID have been working on creating an integrated information system that combines three proven IT solutions into a single, efficient portal: Kuehne & Nagel's 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 many actors are beginning to recognise the value of a number of types of technologies.

Further examples of positive IT also feature in the literature. RFID is mentioned by a number of scholars as a technology with the potential to improve the possible benefits of supply chain management through a reduction in inventory losses, an increase in the efficiency and speed of supply chain processes, and an improvement in information accuracy (Sarac et al., 2009; Matthew et al., 2013). RFID is comprised of three core elements: a tag formed by a chip connected to an antenna, a reader which emits radio signals and receives return data from tags, and a middleware that bridges RFID hardware and enterprise applications (McFarlane et al., 2003). It connects objects to the Internet, allowing them to be traced. The tags are programmable and contain information about destination, weight and a time stamp. These tags allow automation throughout the supply

chain, including the optimisation of warehouse space and the efficient tracking of goods to bring down cost and improve customer service (Matthew et al., 2013).

Mobile phones are another inexpensive technology and make communication between actors in the health supply chain far easier, particularly in rural locations (Riungu, 2011). For example, SMS for Life is a programme developed to improve access to essential medicines for the treatment of malaria in rural parts of Africa. It uses a combination of SMS messages and electronic mapping technology to track weekly stock levels in public health facilities to eliminate stockouts, thus ensuring people have access to life-saving malaria medicines when they are needed (*ibid*). Taking relatively simple mobile phone technology up a level, one technology company, Dimagi, has developed mobile systems for the last mile which transform the capacity of front-line programmes to deliver high-value services to low-resource areas. Their tool, CommCare is a free open-source mobile platform that allows anyone to develop apps, and is currently the most widely adopted evidence-based mobile platform for low-resource settings (Chemonics, 2016). It enables accurate data collection and communication across the supply chain and has the capacity to monitor field worker activities and track end users (*ibid*). Although the complexity of both mobile technologies is vastly different, both offer rural locations the ability to monitor operations and ensure people receive more reliable care.

Another way in which IT has been championed as a potential solution to health supply chain problems and inefficiencies is through its capacity to virtually centralise the supply chain. One example is a Consolidated Service Centre jointly managed and owned by numerous healthcare systems and hospitals (Matthew et al., 2013). Geographically based health facilities can come together to form single entities and centralise procurement, distribution, contracting and logistics (*ibid*). Such an approach helps solve crucial issues relating to staff, budget shortages and time, and the technology could potentially be applied to public health supply chains to strengthen operations.

Blockchain technology has also been highlighted as a means of improving last mile operations in developing countries. It is a digital ledger that facilitates users to transfer digital assets in a cheap, safe and transparent way, without having to depend on a traditional intermediary, such as a bank, to authorise and carry out transactions (Chemonics, 2016). In the case of supply chains in rural areas, blockchain technology can release funds to the drug manufacturer on behalf of patients, pay state health workers instantly, and reduce inventory costs and losses at the same time once the patient receives the treatment they need (*ibid*).

Clearly there is a lot of potential for IT to strengthen public health supply chain operations, but it is important to acknowledge that other components are also required. The success of any software in a system is dependent on a complete understanding, not only of the technology itself, but also of the people who use and oversee it, the processes that relate to it, and the infrastructure that lies behind it (JSI, 2013). Workers require training in how to use new technology so that they can best analyse data to improve supply chain operations. Further, strong partnerships between people and systems working at each stage of the

public health supply chain are necessary for robust communication (Chemonics, 2016), and a strong sense of leadership at the highest level is crucial.

Barriers

While IT presents a great opportunity to improve the functioning of many aspects of public health supply chains, there are some barriers to its widespread implementation. Not least of these is the cost (Schwarting et al., 2011). A proactive approach is required to meet the challenge of transferring technology across industry sectors and from private to public so that end beneficiaries do not miss out on the care they need (Heinbuch, 1995), although incentivising actors to undertake this is difficult.

Further, challenges such as low Internet connectivity can hamper the implementation of effective IT in many rural areas. For example, in Kenya, the sharing of information between health facilities is not always possible due to a lack of Internet, resulting in incomplete data (Riungu, 2011). This has led the government to commit to install computers in all district hospitals to improve on consumption data reporting (*ibid*).

Problems with individual IT can also affect its implementation. RFID technology has been associated with a number of technical issues; it can interfere with other hospital equipment, is not always reliable, and the reading accuracy is highly dependent on factors such as tag placement and the angle of rotation (Matthew et al., 2013). Inevitably high costs are also associated with RFID, such as the initial software and hardware costs, infrastructure upgrade, maintenance and training, and privacy concerns in that use of RFID in a medical context will only be achievable if patients are confident their data will remain secure (*ibid*). It is thus important that strong, clear supply chain business processes are in place to ensure the effective use of this technology. This requires well-trained staff and re-usable, easily modified training tools, such as a series of short online learning videos.

The Future: Overcoming the Challenges

There is a paucity of literature offering experiences and suggestions on how challenges to the implementation of IT in public health supply chains can be overcome. Nevertheless, Frost et al. (2011) do offer some advice on how best to integrate IT into a supply chain system, which they insist must be done with great care. They advise that procedures must be reviewed and streamlined before becoming automated, because automating broken procedures will make existing problems worse than fix them. For example, if a facility is collecting the wrong type of data, it makes no difference whether it comes in on paper or electronically (*ibid*). In addition, technical solutions should be chosen based on a careful evaluation of the system that suggests where the well-defined problem lies, and introducing IT should have a plan going forwards to ensure that it is sustainable and scalable (Frost et al., 2011). This review and streamlining process should occur regularly, as people, processes and technologies change over time.

Frost et al. (2011) also suggest considering a phased approach to introducing IT to public health supply chains, including periodic reviews to determine whether or not to proceed. Solutions should be piloted and then compared against pre-determined measurements, and a decision made about the feasibility of scaling up. Finally, consensus from interested stakeholders should be sought at each stage of the process to incorporate recommendations and advice in a timely manner (*ibid*).

JSI possess a great deal of experience in implementing technological solutions to health supply chains and they recommend working closely with user groups and local stakeholders to determine functional and system requirements, as well as the total cost of ownership, to guide a nation's technology selection (JSI, 2011). Rather than simply introducing new technologies into broken systems, they are committed to fixing the current process prior to implementation. Through business process re-engineering, they eliminate duplications in supply chains, reduce the burden of data collection, and develop Key Performance Indications to measure efficiency (*ibid*).

Clearly, there is a great deal that national governments looking to strengthen public health supply chains can learn, not only from the private sector, but also other sectors in which technology is widely used. This will save time and money and lead to improved supply chains for those who most need care.

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