Application of Geographic Information System (GIS) in Drug Logistics Management Information System (LMIS) at District Level in Malawi: Opportunities and Challenges

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Abstract. District pharmacies in Malawi use a computerised IS to monitor the flow of products from a warehouse to health service delivery points and determine understocked or overstocked products at each health facility. Currently, all drug LMIS reports are in tabular forms. The GIS can help health and drug logistics officers to get additional spatial information, such as locations of health facilities and environmental factors, to the existing reports in the form of maps. This paper highlights some opportunities and challenges of applying the GIS in the drug LMIS, which basically involve technologies, organisation, and standards and data integration. It has been found that this idea is very good but it requires much effort, commitment and resources for successful implementation.

Keywords: Drug LMIS, Geographic Information System, GIS Implementation.

1 Introduction

In Malawi, there is a well established logistics management system which is the medical supply system of inventory management and recording and reporting for health commodities which ensures that all Malawians are able to receive products they need, and receive quality treatment when they visit a health facility. Health commodities move from major stores down to health facilities while the drug logistics information moves from the health facilities to the upper levels.

Currently, the district pharmacies use a computerised IS named the Supply Chain Manager which manages the supply chain information in the health commodity logistics management in the Ministry of Health (MoH). It helps drug logistics and health program managers determine which health facilities are understocked or overstocked among other information. But information on reports generated from this system is only in a tabular form. It is necessary for the drug logistics managers to have information about actual locations of health facilities and road networks for their day-to-day decision making. The GIS can be used in this case to provide such information.

The GIS can be applied in the drug LMIS with the aim to "enrich" the reporting of drug logistics information for the drug logistics and health managers at the district

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level. The managers can use the GIS to get additional information to the existing reports in the form of maps, which would show actual locations of health facilities, and other spatial information including the road network. Therefore, this paper discusses some opportunities and challenges that can exist when introducing GIS in the drug LMIS.

The GIS is one of the issues, which the government of Malawi is considering in its socio-economic policies. Even the MoH has a policy, which recommends the application of GIS in the health sector for instance, the GIS can be used in tracking and monitoring in terms of geographical variations in types and magnitude of problems and equity in distribution of health services across the country as well as service utilisation [7].

2 Literature Review and Theoretical Framework

The GIS does not in itself solve problems of development. It is necessary to consider also non-technical issues such as application environment, organisational issues, data exchange standards, legal issues and human resources.

2.1 Challenges in Implementation of GIS

Many literatures [1, 2, 3, 5, 6, 8, 10] have discussed about challenges, opportunities and strategies of developing and implementing the GIS in developing countries. Although implementation involves a considerable degree of technical issues, they are equaled or surpassed by organisational issues [10]. Croswell [1] argues that the technical side of system implementation and operation is considered “minor” as compared to organisational and institutional problems while standards and data integration are considered very important.

Data collection is one of the most time-consuming and expensive tasks of the GIS but very important because the effectiveness of the GIS depends on the degree of relevant data as input [6, 8]. It has been observed that it is more cost-effective to capture non-spatial data (attributes) separately from the spatial data. This is possible because it is relatively simple task that can be undertaken by lower-cost clerical staff and attributes can be entered directly, which does not require expensive hardware and software [5]. Alternatively, the spatial data can be obtained from external sources and one major decision that needs to be faced is whether to build or buy part or all of a database and the issue of data format. One of the biggest problems with the data obtained from external sources is that they can be encoded in many different formats because no single format is appropriate for all tasks and applications [5].

To fully realise the capability and benefits of the GIS technology, spatial data needs to be shared and systems must be designed and used by multiple organisations. According to Ginger [3] and Croswell [1], data exchange standards have key role to play for facilitating the integration of datasets from various distributed sources or organisations and lack of these required standards between organisations impedes data sharing.

Apart from availability of standardised data, the following are also required [1, 6, 10]: (a) the management (level of commitment, previous computing experiences, and style of leadership); (b) organisation (structure and operation, information flow, distribution of power, and cooperation among participants); (c) technology; and (d) user training including managers.

2.2 Drug LMIS as Installed Base for the GIS

Infrastructures are never developed from the scratch but develop through extending and improving the installed base. When a part of an infrastructure is changed, each new feature or component has to fit with the as-is infrastructure or installed base [4]. The installed base heavily influences how a new infrastructure can be designed i.e. an infrastructure inherits both strengths and limitations of the installed base upon which it builds.

The drug LMIS consists of work processes, systems, users, and procedures among other components. By considering how these components link or integrate, it is possible to identify which parts of the drug LMIS should be improved and extended in order to accommodate the GIS and also to determine which new components of the GIS should be introduced and being integrated with existing components.

3 Methodology

The framed experiment was the one used in this research with the focus on the following: (a) non-standard subject pool which consisted of pharmacy technicians, statisticians and pharmacy-in-charge; (b) experiences and information that the subject pool has with emphasis on the GIS and computer operations; (c) the GIS prototype treated as a new commodity to the drug logistics and health staff; and (d) demonstration of the GIS prototype to the subjects in their respective working places and subjects participated and provided feedback and comments.

The interviews were conducted with the aim of understanding working practices of the drug logistics staff and in the hierarchical manner starting from RMS in Blantyre, in the southern region of Malawi, down to its district pharmacies and district health offices (DHO) in Blantyre and Mulanje districts, and then two health centres in each of the two districts. This was supplemented by analysis of data collection forms and some reports from the Supply Chain Manager and direct observation on its data entry and reporting at Blantyre district pharmacy aiming on finding out how it handles drug logistics data.

Most data was collected through the evaluation of a GIS prototype whose spatial data was collected from the Department of Survey and Roads Authority. The GIS prototype was demonstrated to pharmacy technicians and statisticians from the Blantyre DHO and the pharmacist-in-charge from RMS in their respective working places. It was performed by applying the DECIDE framework [9] and drug logistics and health data of September 2008 was used. The demonstration focused mainly on (a) reporting and analysis of drug logistics information and (b) integration of spatial, drug logistics and health data. After the demonstration participants were interviewed for their feedback on the proposed GIS.

4 Findings

It has been found that the idea of introducing GIS in the drug LMIS is very good but it requires much effort, commitment and resources for successful implementation. Apart from the GIS being used only by the pharmacy technicians, other drug logistics and health staff were also interested in using it.

4.1 The Drug LMIS

The drug LMIS has the health facility, district, regional and national levels. There are a number of officers at each level responsible for managing drug logistics data and each officer has a role to play in LMIS. Data is collected at the health facility level and processed at the district level (district pharmacy) using different tools in order to produce required logistics information for decision making. The responsible level reports within a fixed period of time to the upper level which is supposed to send feedback to the lower level and concerned stakeholders.

For the drug LMIS to function properly, it requires people, data, work processes, tools, equipment, policies, procedures and transport systems among others. The relationships and interactions of these elements and systems form an installed base which the proposed GIS can be built on. Work processes in the drug LMIS include data collection, processing, analysis, and reporting which governed by the standard procedures and policies.

Supply Chain Manager
Ministry of Health
Blantyre District

Stock Imbalances
Report Period: September, 2008
All Facility Type
Health Centre

Run Date:
Run Time: 04:19 PM
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Facility	Product	Closing Balance	AMC	Months of Stock	Quantity Required	Status
Chimembe HC	Sulphadoxine 500mg/pyrimetherine	0	4,000	0.0	12,000	Stocked Out
Bangwe HC	Sulphadoxine 500mg/pyrimetherine	3,000	4,333	0.7	9,999	Below Minimum
Dziwe HC	Sulphadoxine 500mg/pyrimetherine	5,000	6,000	0.8	13,000	Below Minimum
Makata HC	Sulphadoxine 500mg/pyrimetherine	1,000	4,000	0.3	11,000	Below Minimum
Soche HC	Sulphadoxine 500mg/pyrimetherine	2,000	4,000	0.5	10,000	Below Minimum
Zingwangwa HC	Sulphadoxine 500mg/pyrimetherine	13,000	15,667	0.6	34,001	Below Minimum
Chavala HC	Sulphadoxine 500mg/pyrimetherine	21,000	1,667	12.6	-15,999	Overstocked
Limbe HC	Sulphadoxine 500mg/pyrimetherine	11,000	3,333	3.3	-1,001	Overstocked
Lirangwe HC	Sulphadoxine 500mg/pyrimetherine	19,000	2,000	9.5	-13,000	Overstocked
Lundu HC	Sulphadoxine 500mg/pyrimetherine	17,000	2,667	6.4	-8,999	Overstocked
Madziabango HC	Sulphadoxine 500mg/pyrimetherine	10,000	333	30.0	-9,001	Overstocked
Mpemba HC	Sulphadoxine 500mg/pyrimetherine	21,000	1,333	15.8	-17,001	Overstocked
South Lunzu HC	Sulphadoxine 500mg/pyrimetherine	12,000	2,333	5.1	-5,001	Overstocked

Fig. 1. Drug LMIS Report from Supply Chain Manager

The drug logistics data is collected at the health facility by health staff using LMIS forms at the end of every month. Then the LMIS forms are sent to the district pharmacy for processing and analysis using the computerized system, Supply Chain Manager. This system generates different type of reports in tabular form (see Fig. 1) that are sent as hard copies to RMS, district health management team (DHMT), and some stakeholders on monthly basis and on request. The district pharmacy uses these reports to respond to all emergency orders from the health facilities and redistribution of some health commodities from overstocked to understocked health facilities. RMS uses the same information to decide on the monthly distribution of health commodities to the health facilities.

In the drug LMIS, there exist various work processes, users (pharmacists and health staff), tools and equipment (forms, computers and printers), policies and procedures which are linked together in one way or another. The interconnections among these elements or components form the installed base which the GIS as a new system can be built on. It is important to identify which work processes, users` responsibilities, tools and equipment, and procedures among others of the drug LMIS should be extended and/or improved in order to accommodate the GIS.

4.2 The Proposed GIS

For the proposed GIS to be implemented in the drug LMIS, it requires expansions and additions in some areas such as work processes, technologies, people and organisational issues. Work processes in the proposed GIS are data collection, data management, data integration, data processing and analysis, and reporting. Although data collection, reporting, processing and analysis are available in the drug LMIS, they need some extensions in order to be supported in the proposed GIS.

The data collection in the drug LMIS involves only drug logistics data which is part of non-spatial data of the proposed GIS. It is essential to collect spatial data of district administrative boundaries, health facilities, pharmacies and road networks as required in the drug LMIS. Currently, MoH does not collect any spatial data which means that it needs to outsource the services from other organizations, such as the Survey Department, that are already experienced in the spatial data collection. The required non-spatial data includes drug logistics data, health data, and attributes of districts, health facilities, pharmacies and roads. The collection of drug logistics and health data is already in place due to existence of drug LMIS and HIS and what is required is to integrate them with spatial data.

A new work process to be added is the data management which will involve updating of spatial data and attributes. For instance, spatial data used in the GIS prototype has required some updates of districts, health facilities, and road networks. The attributes of health facilities need to be modified now and again.

The data integration is also a new work process to be introduced in the proposed GIS (see Fig. 2). Health managers require drug logistics data and on other hand drug logistics managers require health data on their decision making. Therefore, the proposed GIS can be used as an integration tool to link the logistics and health data together through a common geographical reference system of the health facility.

The specific processing and analysis of drug logistics and health data are performed by their respective systems. For example, the drug LMIS processes and analyses the logistics data which result in the stock status (adequately stocked, overstocked or understocked) of each health commodity and this information can now be integrated with the spatial data and displayed on the map. In some cases it is required to process and analyse data after integration with spatial data for better presentation on the map.

The proposed GIS requires producing reports for use but since the reports contain graphics it is important to consider the best way of production. The map display can be a main method of reporting because it will allow the pharmacy technicians to interact with the map. Printing can be taken as second option when a hard copy is required and it requires high quality colour printing.

Since the GIS should be used at the district pharmacies to support the reporting of drug logistics information, it means that the main user of this system is the pharmacy technician. The pharmacy technician can be assisted by health staff especially in data collection, integration and management. Health facilities are in the management of health staff so it is very important to have them involved. Since it will be the first time to use the GIS at the district pharmacy, it is necessary to train the pharmacy technicians and health staff on how to use the GIS software, tools and equipment. It is also wise to outsource the expertise in human resource or even tools and equipment in the spatial data collection as Mennecke & Crossland [6] point out that data acquisition can be difficult and costly issue in the implementation of the GIS.

The Supply Chain Manager which is used at the district pharmacy only produces reports in tabular form as pointed earlier. For instance, the stock imbalances report (see Fig. 1) of the shows that out of twenty-one catchments health facilities in Blantyre, six were understocked and seven were overstocked but it was not known what happened to other eight health facilities, whether they were adequately stocked, or did not give SP to patients (no consumption), or did not report.

Comparing Fig. 1 with Fig. 3, it was found that the spatial reporting can be a supplement to the original report which shows actual location of the health facility and how far it is from the district pharmacy. It shows that in September 2008, three health facilities did not report any data on SP and only five were adequately stocked. For example in Fig. 1, Chimembe health centre was out of stock of SP and required emergency supply and at the same time three health centres were much overstocked. Therefore, the map (see Fig. 3) would help drug logistics managers to decide which health facilities SP drugs could be transferred from, based on distance and accessibility between understocked and overstocked health facilities.

It is summarised that the existing installed base (drug LMIS) could accommodate the GIS by doing the following: (a) extending the work processes to accommodate the spatial data collection, integration and management; (b) extending policies, procedures and standards for governing the work processes. (c) extending the use of the computers to run the GIS software which would provide tools for integrating the drug logistics, health and spatial data and acquisition of new hardware and software; (d) extending the staff's responsibilities and tasks to those who are involved in spatial data collection, integration and management and in using the GIS software and hardware tools; (e) establishing links between the MoH and other organisations, that deal with spatial data, for sharing of spatial data and outsourcing of expertise (human resource) and tools; and (f) improving the printing quality for colour graphics output of maps. However, there exist challenges and opportunities of fulfilling these suggested activities in order to apply the GIS in the drug LMIS.

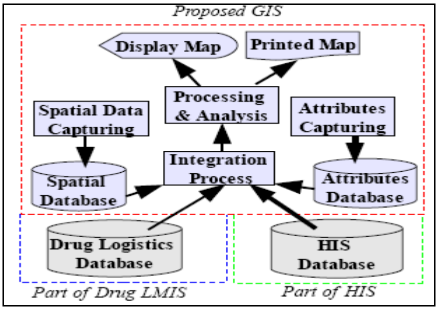

Fig. 2. Integrating Databases of GIS, Drug LMIS & HIS

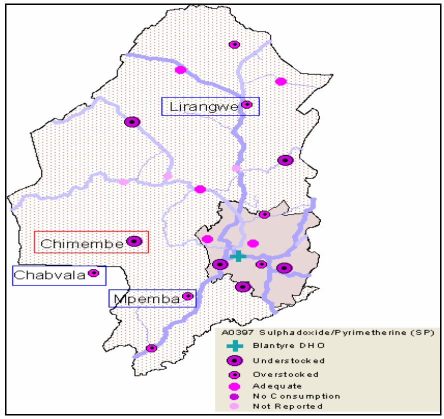

Fig. 3. Generated Map from GIS prototype for Stock Status Reporting

5 Opportunities and Challenges

5.1 Opportunities and Challenges on Standards and Data Integration

The new work processes (spatial data collection, integration and management) are the most time-consuming and expensive GIS tasks but very important because effectiveness of the GIS depends on the degree of relevant data as input. For DHO to successfully implement the GIS in the drug LMIS, it is important to consider carefully data standards and integration particularly between the GIS, drug LMIS and HIS.

The DHO can minimise the cost of building spatial database by outsourcing the expertise from some organisations that are experienced in spatial data collection because this exercise requires well-skilled people, very powerful equipment and also time. The available GPS at DHO can only be used to collect new spatial data for updating the spatial database. It is not necessary to spend a lot of resources to acquire those equipment for and train user on spatial data collection, which is already being done by some organisations. Most of organisations that deal with spatial datasets are from the Government of Malawi which MoH is part of and hence it is very easy to establish relationships between the ministry and those government departments for spatial data sharing.

The main challenge is the data standards for data sharing. Since the spatial data will be outsourced, it is needed for DHO, in particular, and MoH, in general, to determine data standards for easy sharing of spatial data with other organisations because the data from external sources can be encoded in many different formats. For instance, although the Department of Surveys is the national mapping agency and mandated by the legislation to carry out base mapping and control mapping in Malawi, it has its own spatial data standards and formats that may not be relevant to the MoH to use in its GIS as observed in the GIS experiment where the spatial data required some updates before using in the GIS prototype.

DHO requires collecting non-spatial data including drug logistics and health data which should be done separately from the spatial data because it is relatively simple task that can be undertaken by lower-cost staff and attributes can be entered directly which does not require expensive hardware and software. The health and drug logistics data are collected by health and logistics staff using simple materials and equipment such as forms and ordinary computers which means that this process does not require well-skilled person and complicated techniques and equipment as compared to the collection of the spatial data. There are already systems that handle the drug logistics and health data and what the DHO will need is to concentrate on the updates of attributes of health facilities, road networks, pharmacies, districts and other required features in the spatial database.

Although, it is taken to be very cheap to collect non-spatial data at the district level, it is not easy to integrate the data from HIS, drug LMIS and spatial database. Currently, the HIS and drug LMIS are independent systems having their respective policies, standards and procedures. A common identifier is required in all three databases for easy integration and management. It is necessary to determine standards for the common identifier, in this case the health facility and naming of different features such as health facilities, pharmacies and districts. For example, all databases should use the common codes and names for health facilities and pharmacies. If this is to be implemented, it means that the DHO will have a lot of work to modify all codes and names of health facilities and pharmacies in the drug LMIS and HIS to match with those in the spatial database.

If there is a certain change, it will be necessary to update all three databases in order to maintain data consistency and this update will be in hands of two offices the pharmacy technician (for drug logistics database) and statistician (for health database) which require a good coordination. Since both the drug LMIS and HIS will not only be used to feed the GIS, it is important to make sure that the databases have complete data for other services.

Another challenge is a definition of data collection points in the drug LMIS and HIS as experienced in the GIS experiment. In the HIS data is collected from the catchments health facilities while in the drug LMIS data is collected from any health facility which gets health commodities from either RMS or the district pharmacy. It means that to integrate data from the two systems, it is required to define common collection points for both drug logistics and health data. Otherwise data from some health facilities, that are not data collection points in either one of the systems, will be difficult to integrate.

5.2 Opportunities and Challenges on Organisation

The management plays a key role in achieving the GIS adoption and some factors that influence the effective use of the GIS technology are a level of commitment, previous computing experiences, and style of leadership. There are several things that have already been done at DHO. The Government of Malawi in general and MoH in particular have shown some level of commitment on the use of GIS in Malawi in terms of policies and support. The government has come with the GIS policy among socio-economic policies which results in various governmental departments, such as Roads Authority and Survey Department, to be now involved in the GIS. MoH also plays its role to promote the GIS usage by, for example, documenting the GIS policy in the health sector and purchasing GPS for DHO for the spatial data collection.

MoH has already implemented some IS at the district level and experiences that it got during those implementations can be applied to determine ways of implementing the GIS at DHO. The mentioned IS include the district health information system (DHIS) and Supply Chain Manager for the drug LMIS. But it has been observed that these systems are different from the GIS and therefore, the implementation of GIS can be somehow different from those of the two systems. The GIS requires some specific work processes that are not needed in the DHIS and Supply Chain Manager such as spatial data collection, data integration and sharing which require specialised training and equipment, and special consideration in terms of a cooperation among participants from different levels of the drug LMIS and relationship between the Ministry of Health and other institutions including governmental departments.

Currently, at DHO, there are some health and logistics staff members, especially pharmacy technicians and statisticians, who are capable of using different information technologies. They use computer systems in their daily work and have necessary computing skills, knowledge and experiences. It is possible that they can be given further training on the GIS technologies especially on data collection, spatial database management, and use of the GIS software applications.

The issue is now how the user training will be conducted. Some studies have shown that the most programs are normally carried out as part of software training packages and not integrated with the work practices that surround the use of the GIS technology [3]. For the GIS to be implemented successfully, MoH should analyse user needs especially work practices of the pharmacy technicians and health staff in order to incorporate them in the training. It is also necessary to educate the health and drug logistics managers on the benefits of the GIS technologies so that they can provide their necessary support to the implementation of GIS in the drug LMIS. It seems that it will need a lot of effort and commitment in order to conduct the suggested user training because according to the research findings there have been some plans before for user training on the GIS but not yet fulfilled. Since the acquisition of GPS in over four years ago, there has been no any type of training on how to use the technology.

The introduction of GIS will also result on extra responsibilities and tasks to the pharmacy technicians and statisticians who are already overloaded with work due to the lack of human resource in MoH. Alternatively, MoH can outsource the GIS expertise from institutions or organisations such as the Survey Department, particularly on the spatial data collection and building its necessary database. The drug logistics and health staff can only be trained on data management (updates) and use of the GIS software tools.

The effective use of GIS at the district level requires also cooperation among participants from all levels as emphasised by Croswell [1] that the cooperation among participants at different levels of organisations, especially government, is a key to a successful integrated information systems, such as the GIS. The research findings have shown that the cooperation exists in the drug LMIS between staff from all levels, from health facilities up to the national level. MoH in general and CMS in particular need to maintain that cooperation when introducing the GIS. It is very important to extend this cooperation to health staff and other departments in order to, for example, share the spatial data and expertise. Apart from the pharmacy technicians, it has been observed that the GIS would be used by the health staff and logistics staff at the district. All parties should agree on common goals and individual benefits should also be identified.

A sufficient structure, at DHO, is needed for communication channels as well as for resolution of power and control conflicts that can exist due to the introduction of the GIS. Mennecke & Crossland [6] argue that the GIS is likely to have significant impacts on the structure and operation of the organisation. It seems that this can also happen at DHO through changing of the information flow which definitely affects the distribution of power. Through extending responsibilities and tasks of the pharmacy technicians and statisticians, they will get additional power and will definitely share the power with other individuals due to collaborations and interactions. The new operations such as spatial data collection, sharing and integration will also be added to the existing ones. Even Sieber [10] found out that the implementation of the GIS tends to alter the organisation substantively because it is expensive and complex and usually it frequently crosses departmental/subunit lines and alters power relations as the control of information changes.

5.3 Opportunities and Challenges on Technology

The practical work of GIS always involves some aspects of technology which focuses on the computer hardware, software and technical support. The availability of computers, printers, GPS, software systems and users having computing capabilities can be considered as an opportunity in the sense that they will provide technical support to the application of GIS in the drug LMIS. The same computers, that are used in the drug LMIS at DHO, can also be used to run the GIS software. Apart from computers, each DHO has got a GPS which is very important in the spatial data collection due to its advantage of less time-consuming, less expensive, and simpler to use than other techniques such as ground survey, scanning and digitising. The users of these computers, particularly pharmacy technicians, have computing skills and experiences which will provide basic technological background for easy knowledge transfer of the GIS technology when it comes the time of user training.

Availability of the technologies discussed above is not enough to have the full operational GIS in the drug LMIS. Every GIS requires the software tools which include interface, database, analytical and communication tools among others. Currently, DHO has no any GIS software which is in use. It is needed to purchase or acquire necessary GIS software that will provide all required functionalities. For instance, in the United Kingdom well-known GIS products include ArcInfo and ArcView from ESRI, GeoMedia from Intergraph, MapInfo Professional from MapInfo Corp, and GeoConcept from GeoConcept [2]. This shows that there are several GIS software technologies from various vendors or organisations with specific purposes and therefore, it is important for MoH to do a certain software analysis to recommend the most suitable GIS software that will be used in all DHO.

6 Conclusion

The GIS can be taken as the information reporting tool in the drug LMIS in which the GIS will integrate drug logistics data with the spatial data and display on the map. It can be concluded that successful implementation of the GIS in the drug LMIS at the district level in the Ministry of Health will depend on: (a) good evaluation of needs of the pharmacy technicians; (b) long-term commitment to the proposed GIS project of the various program managers in the Ministry of Health especially those dealing with the drug logistics; (c) sufficient allocation of resources and adequate staffing; (d) timely and sufficient training to the pharmacy technicians; and (e) good establishment of cooperation of participants and with other organizations and departments for easy sharing of the spatial data and expertise.

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