# Implementing GIS for Multiple Health Programs in Health Management: Understanding Limitations in the Context of DHIS2 GIS in Malawi

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## ABSTRACT

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## I. ABSTRACT

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## II. INTRODUCTION

Health managers always need health information when they are carrying out their day-to-day activities. Health information is needed for either primary or secondary use. Primary use is when a medical practitioner (e.g. doctor) is getting information to treat a patient while secondary use is when the information is collected for public health program planning, controlling, monitoring and evaluation. The paper focuses on the secondary information.

Health managers need to interpret available information in order to get the required understanding so that they make necessary decisions. This can be achieved by how information is organised, integrated and presented to them. Hence, health information systems (HIS) require relevant technologies and tools for organising and presenting information for easy access and interpretation. One relevant technology is Geographic Information System (GIS), which provides, for example, spatial analysis, integration and visualisation of data. Developing countries like Malawi have realised the power of spatial dimension when dealing with important health issues, which has resulted in adopting GIS.

The paper focuses on the implementation of GIS for health management using the case of DHIS2 GIS in health management information system (HMIS) in Malawi that supports multiple health programs. HMIS is an information system (IS) for health management at different levels [1]. To strengthen the integration of health programs and

accessibility of data from all levels, Ministry of Health (MoH) in Malawi adopted DHIS2 (district health information software version 2), which is the web-based open source software for collection, validation, analysis, and presentation of aggregate and statistical health data. DHIS2 has the module of GIS that is referred to as DHIS2 GIS.

Since the introduction of DHIS2 in Malawi in 2012, reports have been presented in the form of tables and charts. However, static maps have been used since 2002 in some cases in MoH to assist in visualisation of data. Fisher and Myers [2] observe that presenting data in maps can provide more insight than a table of the same data, enabling quick assessment of trends and interrelationships. The main concern with static maps is that they are difficult to update and integrate with other information systems. Hence, in 2015, MoH started the implementation of DHIS2 GIS as the interactive GIS to promote spatial analysis, integration and visualisation in HMIS.

Literature shows that there are a number of limitations faced during the GIS implementation and use, which can be categorised into organisational, data and technical [3, 4]. The paper intends to discuss data and technical limitations. The understanding is that limitations in GIS implementation can differ from one application domain or context to the other. Although studies of GIS in health have been conducted in Malawi such as GIS in TB control [5], GIS in drug logistics management [6] and GIS in HIV/AIDs monitoring and management [7], in common the studies targeted the use of GIS and not exactly the implementation process. In addition, these studies focused on application of GIS in specific health programs. Therefore, this study has focused on the implementation of GIS to support multiple health programs. In this context, a single system, DHIS2 GIS, is expected to meet requirements from multiple health programs with understanding that each health program may have some unique requirements. Therefore, the paper intends to address the following research questions: (1) What are data and technical limitations in GIS implementation for multiple health programs in the developing country context? (2) How can these limitations be addressed for the successful implementation of GIS for multiple health programs?

Research studies on the implementation of DHIS2 GIS in developing countries are limited. Being the first time to implement DHIS2 GIS in Malawi, it was the interest of the authors to explore data and technical limitations associated with the process.

## III. RELATED LITERATURE

GIS has been applied in planning and management of healthcare services [8]. GIS is particularly useful to health professionals and administrators in planning and day-to-day management, since much data used and generated in health has a spatial dimension [9]. One advantage is that GIS integrates common database operations such as query and statistical analysis with the unique visualisation and geographic analysis benefits offered by maps. GIS can be used to combine data and generate information required for decision-making.

According to Maguire [10], GIS is the special case of information system in which "information is derived from the interpretation of data which are symbolic representations of features." That is, GIS is different from other information systems because additionally GIS deals with spatial data. Spatial data is the type of data that is geographically referenced in some consistent manner using, for example, longitudes and latitudes, national coordinate grids, or postal codes [11]. Without adequate and reliable data, GIS is not useful [12].

For spatial data to be captured, stored, processed and generated as maps, technology is required. As an information system, GIS requires technologies (both hardware and software). In addition to the standard hardware components, GIS needs special peripherals for data input (e.g. scanners, digitisers, and GPS), data output (e.g. plotters), and in some cases, data storage and processing

[10]. In terms of software, the special type of computer programs and capable for storing, editing, processing, and presenting geographical data as maps [13]. The software element of GIS includes the database management system (DBMS) for handling and integrating spatial data and attributes.

Literature shows that there are four major limitations, which GIS implementation faces in developing countries – lack of qualified staff, data limitation, high cost of hardware and software, and lack of support from decision-makers. As stated earlier, the paper focuses on data- and technology-related problems. Data is expensive to collect and update; most organisations spend huge part of implementation budget on collecting data and updating it. However, organisations and governments across the globe are promoting data sharing, which has made spatial data to be available and accessed easily. Even collaboration in GIS implementation in developing countries has enabled organisations to capture spatial data. Hence, in this study, the interest is how the spatial data can support different demands from different health programs.

In terms of technology, there are tremendous improvements, for example, "software vendors have begun to develop low cost, easy-to-use products that make the initial investment in GIS more affordable" [14]. Even the recent development of GIS free and open source software have made the availability and accessibility of GIS software to be no longer a big challenge in the sense that they have provided user organisations with a wide range of options for acquiring the technology. Similarly, the paper focuses on how the web-GIS (i.e. DHIS2 GIS) can support multiple health programs.

## IV. CONCEPTUAL FRAMEWORK – COP AND BO

Theories of Community of Practice (CoP) and Boundary Object (BO) guided this study. Researchers have applied CoP in various studies to understand interactions and practices of people in communities [15]. Similarly, in this study, CoP has been used to understand interactions amongst users of DHIS2 GIS. The CoP is a group of people who share a concern or passion for something they do and learn how to do it better as they interact regularly [15]. A CoP is characterised by three elements; domain, community, and practice and it is the combination of these three elements that constitutes a CoP. As a domain, every CoP has an identity that is defined by a shared domain of interest and membership. CoPs have shared competence that distinguishes their members from other people. As the community, members of a CoP need to engage in joint activities and discussions in which they utilise their ideas and build relationships that enable them to learn from each other. In the case of practice, the members of a CoP are practitioners who develop a shared repertoire of resources such as experiences, stories, tools, and ways of addressing recurring problems, which results to a shared practice.

CoPs intersect under a variety of conditions. When two or more CoPs are interacting, data and knowledge are shared across the communities through boundary connectors that are in the form of boundary objects, boundary interactions and boundary spanners (brokers) [15]. Interaction and brokering are more of participation involving mainly a human being while boundary objects are artefacts. Since, in this study, the interest is on spatial data and DHIS2 GIS as artefacts, the theory of boundary object is used.

Boundary object theory has been applied to study interactions that take place and objects that people create and use in the context of crossing the boundaries of different social worlds such as CoPs [16]. Bowker and Star [17] define boundary objects as "objects that both inhabit several communities of practice and satisfy the informational requirements of each of them." They further argue that boundary objects should be plastic enough to adapt local needs of parties employing them and robust enough to maintain a common identity across sites, that is, weakly structured in common use and strongly structured in individual use [17]. A boundary object, when

identified by multiple communities, serves as a common point of reference to facilitate conversation around contested issues thereby enhancing mutual understanding in the process.

In order for the object to be a boundary object, it requires to satisfy certain properties, which Wenger [18] suggested as *modularity* – actors in CoPs use only those subsets of the provided information that is needed for their tasks; *abstraction* – removing details that are not relevant to the stakeholders whilst still remaining the common identity across CoPs; *accommodation* – information is generic enough to assist different activities; and *standardization* – the object is interpretable by diverse stakeholders.

## V. RESEARCH METHODOLOGY

This is the qualitative interpretive case study conducted in Malawi at the national level of Ministry of Health from March 2016 to January 2017. To strengthen its health management information system (HMIS), Ministry of Health established Central Monitoring and Evaluation Division (CMED) in the department of Planning and Policy Development. CMED coordinates HMIS and DHIS2 is the formal health information system.

### *5.1 Data Collection*

In this study, participant observation was the main method for data collection, which was supplemented with interviews and analysis of documents and spatial data.

#### *5.1.1 Document and Spatial Data Analysis*

Various documents were analysed, which were national bulletins, Health Information System - National Policy and Strategy of 2003, Malawi National Health Information System Policy and Malawi Health Sector Strategic Plan. These documents were analysed to understand issues concerning the implementation of DHIS2 GIS. Other documents were guidelines, policies, facility report monthly forms of nutrition and malaria programs as example of health programs for DHIS2 GIS. The health programs were selected randomly. These documents were analysed to understand the health data elements and indicators required for nutrition and malaria programs in DHIS2.

Besides analysing the documents, the authors also analysed spatial data of health facilities collected by MoH and UNICEF and that of administrative districts from National Statistical Office. Spatial data is the key component of every GIS application [10, 19] and it was important to check if the data was adequate and complete before starting the DHIS2 GIS deployment.

#### *5.1.2 Semi-structured Interviews*

Interviews were conducted to understand user requirements and to establish if functionalities in DHIS2 GIS were to meet those user needs. Informants included:

- Four health program coordinators for nutrition and malaria programs in two health districts of Mchinji and Blantyre were interviewed on the flow of data concerning their respective programs and how it was captured into DHIS2, which indicators their programs used, how they presented their reports and challenges they encountered when accessing the data from DHIS2.
- Four HMIS officers in the same two health districts were interviewed on how they captured data into DHIS2, the technical support they provided to other users, their expertise in GIS and challenges they encountered when using DHIS2.
- Two DHIS2 programmers were interviewed on their role in DHIS2 and level of expertise in GIS.
- Two CMED officials were interviewed on background of GIS in health management in Malawi and GIS implementation strategy.
- Two representatives from UNICEF, as of development partners interested in DHIS2 GIS and provided support, were interviewed to understand their role in DHIS2 GIS.

All interviews were conducted at the individual's workplaces. During interviews, data was tape-recorded. Immediately after the individual interview recorded data was transcribed into text and notes were written up in full and sent to the respective participant for verification.

### 5.1.3 Participant Observation

Participant observation was done during the deployment of DHIS2 GIS. The authors participated in key activities from June 2016 to January 2017. They attended two meetings and two workshops. At the first meeting, UNICEF and CMED deliberated on DHIS2 server migration and GIS user needs. At the second meeting, UNICEF and CMED discussed on how to deploy DHIS2 GIS.

The deployment of DHIS2 GIS involved user needs analysis, spatial data preparation, DHIS2 GIS setup and DHIS2 GIS evaluation. The whole process took six months and done by the authors with support from DHIS2 programmers and UNICEF officials.

- *User needs analysis* assisted in determination of the system requirements for the DHIS2 GIS in Malawi.
- *Spatial data preparation* was in three stages: spatial data acquisition, spatial data pre-processing and spatial data verification.
- *DHIS2 GIS set-up* took three months in which health facilities were assigned to their respective facility types; duplicates were resolved; misspelled health facilities were corrected; missing health facilities were created; and coordinates were imported into DHIS2.
- *DHIS2 GIS demonstrations* were conducted to health program coordinators and HMIS officers in Blantyre and Mchinji districts, UNICEF officials and CMED management. Demonstrations focused on map creation and data visualisation from different tools such as tables, charts and maps. Participants were giving comments and suggestions during demonstrations.

### 5.2 Data Analysis

The authors used content analysis method to analyse the data. Content analysis involves extracting major themes from the verbal or behavioral collected data and categorizing them for the purposes of classification, summarizing and tabulation [20]. Major themes and categories were identified from transcribed data and data collected through observations and document analysis. Thereafter, the findings were drawn based on the themes and categories.

## VI. FINDINGS AND ANALYSIS

### 6.1 CoPs and DHIS2 GIS as a Boundary Object

Any management, like health management, requires collaboration among actors from different groups, departments and organisations [21]. As in this study of DHIS2 GIS implementation in Malawi, these groups include CMED management and health program managers at the national level, and HMIS officers and health program coordinators at the district level. The CMED management has health statisticians, health economists and M&E officers who act as technical advisors to health program managers. Generally, the interaction between district and national levels is within, for example, health programs (i.e. coordinators and managers). Technical support personnel also interact (i.e. HMIS officers and CMED management). As Kanjo and Kaasboll [22] argue that management levels in health system can be treated as communities of practice (CoPs), in this study, district and national levels are treated as CoPs. Health programs and technical support team (as a division) are also taken as individual CoPs. When these CoPs are interacting, boundaries exist and data is transferred to accomplish their common goal of managing health data. To share the data across these CoPs, connectors are required and in this case, DHIS2 GIS is treated as one of them as illustrated in Figure 1.

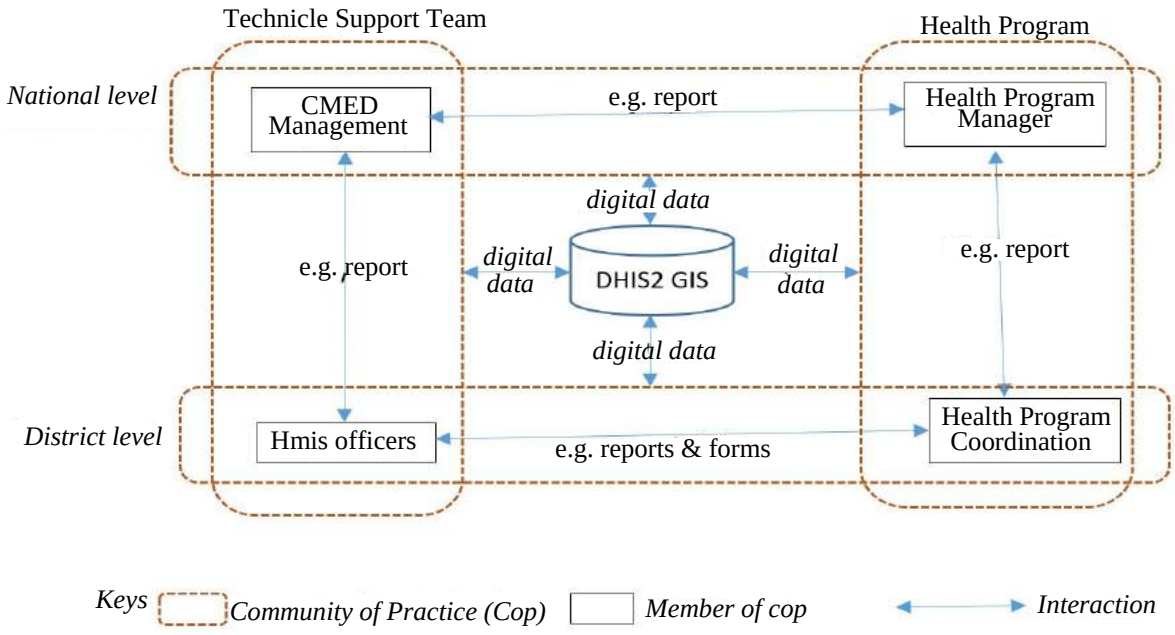


*Figure 1:* CoPs in DHIS2 GIS implementation and use in Malawi

When building a boundary object (i.e. DHIS2 GIS and spatial data in this case), it has three attributes: its content (the scope of knowledge inscribed in it), the technology that goes into its construction, and the practices which go into the utilization of the knowledge [16]. DHIS2 GIS is viewed as a socio-technical entity and it cannot be introduced without studying its social context. Its implementation in the health management requires interactions between people and technology, through sharing of spatial data and maps, which have social and technical attributes (i.e. content, technology and practices).

At district level, health program coordinators and HMIS officers are the main users of DHIS2 GIS. The main role of health program coordinators in DHIS2 is to manage health data at district level. These coordinators receive aggregated data from all health facilities in the district for their respective health programs. They verify the data by ensuring that it has no anomalies. After verification they enter the data in DHIS2, which is accessed by different stakeholders at different levels. However, it was observed that due to other official engagements, health program coordinators mostly delegate data entry to HMIS officers. Health program coordinators produce reports from DHIS2 for use when providing health care services to communities. They also share their reports with their respective health managers and other stakeholders when a need arises.

HMIS officers provide data management services and technical support to program health coordinators and other stakeholders. They ensure that data in their respective health districts is entered into DHIS2. For health program coordinators to access DHIS2, they need to have user accounts. It is the responsibility of HMIS officers to create those accounts and ensure that they have assigned the required roles to all users in their respective health districts. Assignment of roles assists to control activities that users can do on data in DHIS2 such as entering, viewing and updating.

At national level, health program managers and CMED management are the key users of DHIS2 GIS. Health program managers use data in DHIS2 for planning and monitoring services. It was observed that health program managers aim at providing adequate health services across the country. For these health managers to effectively use DHIS2 GIS, they need support from the CMED management. The CMED management provides necessary technical support at all levels.

It is the responsibility of the CMED management to implement new tools in DHIS2, which would be of help to manage health data. the CMED management also implements new technologies to address the requirements of health programs. It also ensures that users are able to use the system by providing accessibility, user documentation and training. When health program managers and other stakeholders need health data at national level in the country, the CMED management produces reports using data from DHIS2.

### 6.2 Spatial Data Limitations

In this study, the key limitation is the incompleteness of spatial data. According to Langaas and Tveite [23], spatial data completeness is an indication of whether or not actual data available is able to meet current and future user needs. Table 1 summarises spatial data limitations identified in this study.

*Table 1:* Observed Spatial Data Limitations

| Limitation | Description | Action or Requirement |
|---|---|---|
| Missing health district boundary | The health district boundary is modeled using administrative or political district boundary. One district of Mzimba has two health districts and their spatial data was not available. | Created using *dissolve* in GIS software |
| Missing facility coordinates | One central hospital (referral hospital) had no coordinates | Captured from Google maps |
| | Some private clinics had no coordinates | Lack of resources to capture data |
| Population distribution | Knowledge of population would assist in health managers to deploy required resources in health facility. The available spatial data did not include population distribution. | Upgraded DHIS2 GIS to the latest version that connects to Google Map Engine to access population distribution layers |

### 6.3 Technical Limitations

Inaccuracies caused by technical limitations in GIS can have significant consequences [24]. Graeff and Loui [24] suggest that technical limitations may be due to inaccuracies introduced when preprocessing spatial data and incompatibilities of data sets stored in different formats, which can be mitigated, by consistency checks and use of technical standards. Hence, Table 2 summarises the technical limitations observed by assessing DHIS2 GIS functionalities against the user demands.

*Table 2:* Observed Technical Limitations

| Limitation | Description | Action or Requirement |
|---|---|---|
| 'Zero value' and 'no value' representation | In DHIS2, zero (0) means a 'zero' as the value whilst blank () means 'no value' or value not reported. However, in DHIS2 GIS both are represented in the same way of not showing an associated feature on the map. Hence, users do not know whether a facility has reported that data or not. | Needs programming in new versions |
| 'no value' and no boundary spatial data | When analysing per catchment area, there exists a failure of not showing a catchment area having 'no value' or no boundary spatial data. This is similar to the above limitation. | Needs programming in new versions |
| Accessibility of DHIS2 GIS | DHIS2 GIS is accessible by multiple users. However, accessibility is affected by electricity and internet connections disruptions; internet speed (when it is slow GIS fails to download maps); | Infrastructure improvements |
| | User access is controlled through user accounts. Hence, some potential users have no access to DHIS2 GIS because they do not have accounts. | Create accounts but limited by access privileges |
| Map sharing | Maps are shared through dashboards, 'favourites' feature, or download as picture or PDF. However, the download fails to include facility layer and features from Google layer. | Needs programming in new version |

## VII. DISCUSSIONS

Findings have shown that DHIS2 GIS is a shared system. In this study, three objects within DHIS2 GIS are treated as boundary objects: GIS as technology, spatial data, and maps generated from the system. On the one hand, the limitations are in line with these boundary objects. On the other hand, the paper focuses on three 'powers' of GIS – analysis, integration and visualisation, which the limitations are related to.

Different CoPs are using DHIS2 GIS. A user in one CoP can enter data in the system and users from other CoP are able to access that data. In this context, DHIS2 GIS is taken as a boundary object for communication as it is interfacing the users from different CoPs. Findings have also shown that DHIS2 GIS houses data for different health programs and the users from each health program are able to get a subset of the data as per their needs. In fact, this observation is in line with Pawlowski and Raven [25] who argued that shared information systems are boundary objects. In order for the DHIS2 GIS to be the suitable boundary object, it should have properties such as abstraction, modularity, accommodation, and standardization. It has been observed that the limitations identified in this study affect these properties which may lead to difficulties in analysis, integration and visualisation in DHIS2 GIS.

### *7.1 Abstraction*

This property emphasises that the boundary object should contain only details relevant to the stakeholders [18]. In the case of DHIS2 GIS, it should contain data relevant to all health programs. Details of spatial data, which are not relevant to health programs in DHIS2 GIS, have not been captured. Spatial data for health facilities and health districts are the ones available in DHIS2 GIS for all health programs to use. It is possible to integrate these spatial data with data elements and indicators in DHIS2 GIS to support the analysis and visualisation. However, there are still some limitations with the system due to lack of some boundary object properties such as modularity, accommodation and standardization.

### *7.2 Modularity*

DHIS2 GIS allows users in health programs to extract subsets of data needed for their individual tasks. For example, they can analyse and visualize data in DHIS2 GIS per health facilities, health districts and levels of their choice. The observation is that some groups of users fail to meet their needs in some circumstances due to the missing of required spatial data. The missing of spatial data for some features like health facilities contribute to the lack of modularity in DHIS2 GIS in the sense that some output cannot be generated. Lack of important DHIS2 GIS functionalities can also affect the modularity by hindering some users to get the information they want. Examples include the failure of visualising 'zero value' and 'no value' representation.

### *7.3 Standardisation*

This is another important property in DHIS2 GIS as the boundary object, which enhances the common interpretation among users of the system [18]. One issue is on the health facilities; there is a standard way of naming them by adding the facility type to facility names. In the case of duplications, its parent facility name is embedded in the facility names. Another issue is on the management levels: nation, zone, district, facility and community. In DHIS2 GIS, the organisation units are organized in the hierarchy following these levels. Hence, it is easy to analyse, integrate and visualize data in the GIS. Limitations associated with this property are related to the technology in terms of visualisation; for example, difficult to differentiate 'no value' and no boundary spatial data.

### *7.4 Accommodation*

The majority of limitations are towards the lack of DHIS2 GIS to accommodate some groups of users. The DHIS2 GIS is expected to support all users to carry out their different activities. However, this is difficult because some spatial

data is missing; the system fails to accommodate some functions; and users fail to access the system when they need it. These three identified concerns are related to each other. On the one hand, it is possible to have all needed data but the system fails to manipulate it for meeting certain user needs. On the other hand, the system can be perfect but there is no data to process. In addition, the system is perfect and data is available but the system is not accessible. As Culnan [26] puts it, in online information systems, accessibility encompasses physical access to the hardware components (i.e. the server hosting the system) and access to the actual information on the server.

The accessibility in DHIS2 GIS limits its accommodation in two dimensions; registered users fail to access and unregistered users fail to get information from registered users. As mentioned earlier, only registered users are able to access resources of DHIS2 GIS and their accessibility is affected generally by the infrastructure. However, other people who are not registered users want to access maps generated from DHIS2 GIS but they fail because, for example, of difficulty in map downloading for sharing.

### 7.5 Reducing Limitations

In order to minimise the identified data and technical limitations, this paper has suggested two strategies: spatial data completeness and technology upgrade. By having the complete spatial data and upgrading the technology, the usability and shareability of DHIS2 GIS can be improved. However, the infrastructure should be stable in order to access DHIS2 GIS with minimum hassles. As illustrated in Figure 2, by making spatial data to be complete and upgrading DHIS2 GIS, it is possible to enhance the accommodation, abstraction, modularity and standardization of the system as the boundary object and then it will be able to handle required analysis, integration and visualisation.

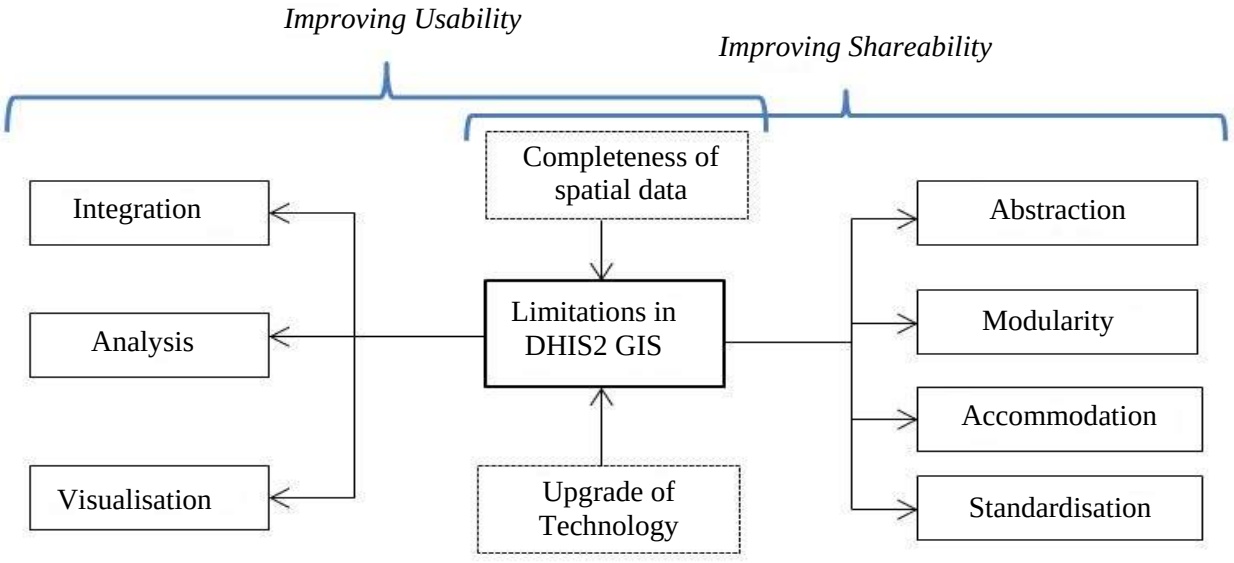


*Figure 2:* Proposed strategies for minimizing the limitations

Spatial data completeness can be achieved through data sharing by different institutions and equipping local users, such as HMIS Officers, with knowledge and necessary gadgets like Global Positioning System (GPS) so that they should be able to collect spatial data for new requirements and themes in their respective catchment areas. In this case, the datasets would be complete. Spatial data sharing should be promoted to minimize costs involved in data capturing.

With respect to technology upgrade, the paper suggests three ways – migration, customisation, and core programming. As observed with the example of population distribution, it is possible to minimise some technical challenges by

migrating to new versions of the GIS software. However, this process requires adequate local expertise and sharing of knowledge with users through training, for example. In some cases, GIS software can be customised to fit for the context use. This process is possible mainly if the GIS software is free and open source. This process also requires local expertise or access expertise from other organisations through, for example, collaboration. As observed in this research, core developers need to program some functionalities of a concerned GIS software. Majority of technical limitations identified in this study require such type of programming as shown in Table 2.

## VIII. CONCLUSION

The aim of the paper was to explore data and technical limitations in GIS implementation for multiple health programs using the case of DHIS2 GIS in Malawi. This case study found out that the key limitations are the incompleteness of spatial data, inaccuracies in data processing and accessibility of DHIS2 GIS, These challenges may affect the accommodation of DHIS2 GIS as the boundary object to different health programs. DHIS2 GIS is expected to support all users to carry out different activities. The paper has suggested the spatial data completeness and DHIS2 GIS upgrade (i.e. migration, customisation and 'core' programming) as ways of improving the usability and shareability of the system. However, both ways need adequate resources particularly expertise.

## REFERENCES


1. Asangansi, I., *Understanding HMIS Implementation in a Developing Country Ministry of Health Context - an Institutional Logics Perspective*. Online Journal of Public Health Informatics, 2012. **4**(3).
2. Fisher, R.P. and B.A. Myers, *Free and simple GIS as appropriate for health mapping in a low resource setting: a case study in eastern Indonesia*. International Journal of Health Geographics 2011, 2011. **10**(15).
3. Sieber, R.E., *GIS implementation in the grassroots*. Journal of the Urban and Regional Information Systems Association, 2000. **12**(1): p. 15-29.
4. Ibrahim, S. and A.A. Kuta, *Challenges in using Geographic Information Systems (GIS) to Understand and Control Crime in Nigeria*. IOSR Journal Of Humanities And Social Science (IOSR-JHSS), 2015. **20**(3): p. 43-48.
5. Nyirenda, T., et al., *Not just pretty pictures: geographical information systems (GIS) in tuberculosis control – experience from Malawi*. Malawi Medical Journal, 2005. **17**(2): p. 33-35.
6. Chikumba, P.A., *Application of Geographic Information System (GIS) in Drug Logistics Management Information System (LMIS) at District Level in Malawi: Opportunities and Challenges*, in *Department of Informatics*. 2009, University of Oslo: Norway.
7. Msiska, B., *Challenges and Opportunities in Using GIS for Monitoring and Management of HIV/AIDS: A Case Study from Malawi*, in *Department of Informatics*. 2009, University of Oslo: Norway.
8. Parker, E.B. and J.L. Campbell, *Measuring access to primary medical care; some examples of use of Geographical Information Systems*. Health & Place, 1998. **4**(2): p. 183–193.
9. Johnson, C. and J. Johnson, *GIS: A Tool for Monitoring and Management of Epidemics*, in *Mapping India 2001 Conference*. 2001: New Delhi, India.
10. Maguire, D.J., *An overview and definition of GIS*, in *Geographical Information Systems: Principles and Applications*, D. J.Maguire, M.F. Goodchild, and D. Rhind, Editors. 1991, Wiley & Sons, Inc.: New York
11. Awange, J.L. and J.B.K. Kiema, *Environmental Geoinformatics: Monitoring and Management*. Environmental Science and Engineering, 2013.
12. Longley, P.A., et al., *Geographic Information Systems and Science*. 2nd ed. 2005, West Sussex: John Wiley & Sons Ltd.

13. Campbell, J. and M. Shin, *Essentials to Geographic Information Systems*. 2011, New York: Flat World Knowledge, Inc. 170.
14. Mennecke, B.E. and L.A. West Jr., *Geographic Information Systems in Developing Countries: Issues in Data Collection, Implementation and Management*. Journal of Global Information Management, 2001. **9**(4): p. 45-55.
15. Kanjo, C., *In Search of the Missing Data: The case of maternal and child health data in Malawi*. 2012, University of Oslo: University of Oslo.
16. Puri, S.K., *Inregrating Scientific with Indigenous Knowledge: Constructing Knowledge Alliances for Land Management in India*. MIS Quarterly, 2007. **30**(2): p. 355-379.
17. Bowker, G.C. and S.L. Star, *Sorting Things Out: Classification and Its Consequences*. 1999, Cambridge, MA: MIT Press.
18. Wenger, E., *Communities of Practice: Learning, Meaning, and Identity*. 1998, Cambridge: Cambridge University Press.
19. Raju, P.L.N., *Fundamentals of Geographical Information System*. Satellite Remote Sensing and GIS Applications in Agricultural Meteorology, 2006: p. 103-120.
20. Hsieh, H. and S.E. Shannon, *Three Approaches to Qualitative Content Analysis*. Qualitative Health Research, 2005. **15**(9): p. 1277-1288.
21. Jensen, S. and A. Kushniruk, *Boundary Objects in Clinical Simulation and Design of eHealth*. Health Informatics Journal, 2016. **22**(2): p. 248-264.
22. Kanjo, C. and J. Kaasboll. *Influence of Information Generated from Traditional Practices on HIS*. in *11th International Conference on Social Implications of Computers in Developing Countries*. 2011. Kathmandu, Nepal.
23. Langaas, S. and H. Tveite, *To Characterise and Measure Completeness of Spatial Data: A Discussion Based on the Digital Chart of the World (DCW)*, in *5th Scandinavian Research Conference on Geographical Information Systems*. 1995: Trondheim, Norway.
24. Graeff, C. and M. Loui, *Ethical Implications of Technical Limitations in GIS*, in *Technology and Society Magazine*. 2008, IEEE.
25. Pawlowski, S. and A. Raven. *Supporting Shared Information Systems: Boundary Objects, Communities, and Brokering*. in *ICIS 2000 Proceedings*. 2000.
26. Culnan, M.J., *The Dimensions of Accessibility to Online Information Systems: Implications for MIS Implementation*, in *ICIS 1983 Proceedings, 4*. 1983.

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