

Standardizing a developing country health information system through proprietary software: Ghana's experience

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Abstract

This study aims to understand a developing country's experience with health information system (HIS) based on standard proprietary software compared with that based on free and open source software (FOSS) as documented in the literature. The developing country HIS literature has focused more on experiences with manual systems or FOSS. Less is therefore known about the development and use of HIS based on standard proprietary software. Using qualitative, interpretive case study methodology, this study investigates Ghana's experience with the development and use of proprietary software to standardize HIS across the national, regional, district and hospital levels. The paper highlights the inflexible nature of the standardized proprietary approach to HIS under top-down development in developing countries and the resultant challenges and recommends FOSS based on bottom-up participatory development as a better alternative.

Keywords. Health information systems; proprietary software; free and open source software; standardization; developing country; Ghana.

1. Introduction

The purpose of this study is to understand a developing country's experience with health information system (HIS) based on standard proprietary software compared with that of free and open source software (FOSS) as documented in the literature. Proprietary software is delivered with closed source code and under a commercial license that restricts users from modification and customization. An alternative is free and open source software (FOSS), which is delivered with open source code, allowing users to modify it to suit their custom needs (1). Despite its closed source nature, proprietary software has some benefits such as having been tried and tested and availability of vendor support, albeit at a cost. However, its disadvantages such as vendor lock-in, high licensing costs and inflexibility for customization are well noted (2-3). FOSS has thus been considered as a more flexible and less costly alternative for HIS (3-4).

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Traditionally, health services in developing countries have been centralized at the national level, under the management of the National Health Service (NHS). Following the World Health Organization (WHO)'s recommendations, some developing countries have decentralized by creating regional health services (RHSs) and district health services (DHSs) to support quality care at the lower level (5). Decentralized health services call for decentralized HISs (5-6) to ensure that varied information needs at the lower levels (districts and regions) and standard information needs at the national level are well met at the same time (7-8). While the NHS needs standard information to support national health policies and decision making, the districts and regions need custom information to support health care management and decision making at their own levels.

Achieving the balance of standard information needs for the national level and varied custom information needs for the lower levels at the same time has been a difficult task for many developing countries (4), especially for those using manual systems. Following South Africa's successful deployment of district health information system (DHIS) based on FOSS to support their health services decentralization, some developing countries have adapted it to their decentralization programmes (9-10). FOSS-based DHIS has subsequently attracted much research in the developing country HIS literature (e.g.7, 11).

However, not much is known about HIS based on standard proprietary software. To address this research gap, this study follows qualitative, interpretive case study methodology (12-13) to investigate Ghana's experience with development and use of standard proprietary software for HIS across the national, regional, district and hospital levels. The research question that motivated the study is therefore about why and how a developing country adopted standard proprietary software for its HIS and the consequences thereof.

The rest of the paper is organized as follows. Section 2 reviews the literature on developing countries HIS. Section 3 describes the research context and the methodology. Section 4 presents the research findings. Section 5 discusses the findings. Finally, Section 6 concludes the paper with its contribution, implications and suggestions for future research

2. Health information systems in developing countries

Developing country health services and related HISs had traditionally been centralized at the national level. However, following WHO (14-15) recommendations, most countries have decentralized their health services and HIS to support quality care at the grass-root levels (5, 7, 16). Decentralized health services in developing countries are hierarchically structured into national, regional and district levels (7). Alongside this structure, HISs have also been decentralized. District health information systems (DHISs) have been created to serve as the hub of information for all levels (5, 17). The role of DHISs is to gather data from hospitals and clinics, analyse the data for use at that level and submit aggregate reports to the regional health services (RHSs) to also

submit higher level aggregates to the NHS for policy planning, development and evaluation (7, 17-18).

For most developing countries, deploying an effective DHIS has been a difficult challenge (7, 19) due to complex and bureaucratic administrative structures, limited resources, and disparate information systems (ISs) (7, 17-18, 20). Another difficulty is how to integrate HIS under the hierarchical reporting structure with that of donor and government sponsored vertical programmes such as for HIV/AIDS and malaria control (5) which often develop their own ISs and reporting channels (21). Another key challenge is how to balance standard information at the national level and varied, custom information needs at lower levels (22). Braa and Hedberg (11) conceptualize this as the paradox of tension between flexible information needs at the district level and standard information needs at the national level. However, experiences of South Africa and some developing countries show that FOSS-Based DHIS has the capability and flexibility to address the tension between flexible information needs and standard information of the lower and upper levels respectively (7).

FOSS-Based DHIS was initially developed in South Africa by its Health Information Systems Programme (HISP) to support district-based decentralization of health services (11, 18). The software development followed participatory, bottom-up approach that incrementally involved users at various levels (11) in order to meet information needs at both the lower and the national levels (22). Following successful initial implementation in selected districts, it was replicated across all districts and provinces in the country and subsequently became the national software for HIS (7, 11, 23). It offers several functionalities, including validation controls, custom report generator, interoperability, and customization (17, 24). After successful deployment in South Africa, DHIS has been adapted in several developing countries, such as Tanzania, Malawi, Nigeria, India, Botswana, Mali, Sierra Leone, Vietnam and Cuba (see 10, 18, 24, 25). Current versions are web-enabled and available for download by other developing countries (26).

The success of DHIS has largely been attributed to its FOSS and participatory development approach. FOSS presents several benefits to developing country health systems (2). It offers opportunity to reduce total cost of software ownership (24, 27) and for flexibility as well as removal of vendor lock-ins from proprietary vendors (3). Unlike proprietary software, FOSS offers opportunity for local adaptation. Its flexible nature is suitable for addressing flexible-standard information needs paradox (7). FOSS also offers capability for interoperability with other software and extendability to new areas such as vertical programmes (7, 27). In some countries, it has been modified to integrate with other applications such as electronic patient records (18).

There is the opportunity for other developing countries to join online open source communities share experiences with others and learn from them. As pointed out, developing quality DHIS is beyond the capability of individual countries (18). HISP network support online communities for countries to share experiences and learn from each other (18, 27). Although some countries have encountered challenges in adapting DHIS to their environment, most of such challenges have been less technical and more social, such as power struggles, lack of skills, and user resistance (25). HISP is however available to provide the necessary technical support where necessary.

However, one key challenge most developing countries need to address in order to benefit from FOSS is lack of programming skills to support FOSS adaptation (1, 4, 26). Developing country governments have therefore been advised to invest in local computer skills without which the promised benefits of FOSS may not materialize (3).

3. Research setting and methodology

This study forms part of a larger research project into HIS in Ghana. The current research investigates Ghana's experience with the development and use of standard proprietary software. Ghana is a developing country in Sub-Saharan Africa with a population of over 24 million. The country is administratively divided into 10 regions and 212 districts. The health sector is hierarchically structured alongside the administrative structure into four levels: national, regional, district and sub-district/community as shown in Figure 1.

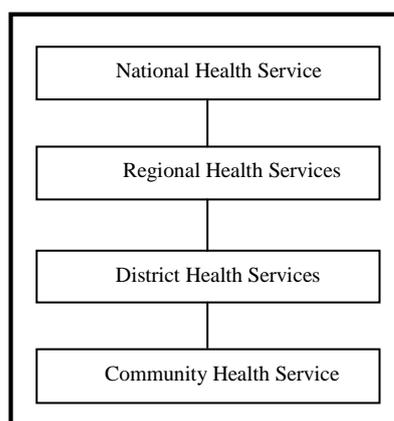


Figure 1. Ghana's health service structure

The National Health Service (NHS) is responsible for the overall health care management in the country and reports to the Ministry of Health, which formulates policies for the sector. The regional health services (RHSs) coordinate health care management at their levels and report to the NHS. The district health services (DHSs) are responsible for health care at their levels and to the RHSs. Finally, the community health services (CHSs) manage health care at that level and to the DHSs. Public health facilities are roughly categorised alongside the health service structure into teaching, regional, district, and community hospitals/clinics. Available data (28) shows that by 2009 Ghana had 3 teaching hospitals, 8 regional hospitals and 95 district hospitals. Besides the public facilities, there are several private hospitals and clinics as well as vertical programmes such as for HIV/AIDs, malaria, and maternal and child care. Until 1994, Ghana's HIS was purely manual. Since then, it has undergone computerization reforms such as introduction of spreadsheet application followed by standard proprietary software in 2004. This study focuses on the country's experiences before, during and after the introduction of the standard proprietary software.

3.1. Methodology

In order to gather and analyse in-depth data about the research phenomenon and its context, we followed qualitative, interpretive case study methodology (12-13). The ontological and epistemological perspective of interpretive philosophy (12, 29) is that research phenomenon and knowledge are socially constructed between researchers and their participants (30). Unlike positivist research which seeks objectivity, interpretive research seeks subjectivity by looking for meanings that people assign to a phenomenon (31). In IS research, interpretive case study investigates contemporary phenomenon in its real-life context (32), focusing on social actions and interpretations surrounding the design, development, implementation and use of information systems (12, 31). Interpretive case study has therefore been considered useful for understanding IS phenomenon in organisational and societal settings (12, 31). It has equally been found useful for investigating HISs (e.g.22, 33-34). Consequently, we also find it appropriate for studying experiences related to development and use of standard proprietary software for HIS.

3.2. Data Gathering

We negotiated and gained research access to the health sector through a formal letter to the Director-General of the Ghana Health Services, who granted a written permission for the study. Fieldwork for data gathering occurred in two phases. The initial one occurred between August and October 2011. This was followed by the second fieldwork from February to April 2012 to verify emerging findings from the initial analysis. We gathered documentary and interview data from the NHS, 6 RHSs, 25 DHSs and 14 hospitals as shown in Table 1. CHSs and vertical programmes were excluded because they did not use the standard proprietary software. Participants were identified through purposive sampling (35-36) that involved locating people with knowledge about the standard proprietary software.

As interpretive research depends on multiple data sources (13), we gathered data from interviews, observation, documents and artefact analysis. We conducted 73 semi-structured face-to-face and telephone interviews with a cross-section of health and health related professionals including managers, HIS professionals, administrators, information officers, and coordinators. Telephone interview became important due to the geographical spread of participants across the country. On the average, formal interviews took between 30 to 60 minutes. Depending on the wish of participants, the interviews were recorded through a combination of tape-recording and note-taking and subsequently transcribed after each session as soon as possible.

Table 1. Levels and number of interview participants

Level	Participants	Number
National (1)	Managers	3
	HIS Professionals	8
Regional (6)	Information Officers	15
District (10)	Information Officers	28
Hospitals (6)	Health Administrators	8
	Information Coordinators	11
Total		73

We also gathered data from informal conversations with managers, administrators, professionals and directors through face-to-face, telephone and e-mail exchanges. Additional data came from participants at the 2011 Annual Conference of Health Service Administrators of Ghana, where both researchers were invited speakers on HIS in Ghana. Participants at the conference included health professionals from all parts of the country.

Relevant documentary sources including periodic reports from the NHS, RHSs and DHSs as well as newsletters, newspapers and internet search also provided data. Additional data also came from our analyses and observation of the standard software in use in 6 hospitals, 3 districts, 2 regions and the NHS. These sites were also chosen through purposeful sampling (35). The second author's background as a former hospital administrator helped in gaining access to the various data sources.

3.3. Data Analysis

In line with interpretive research tradition (12-13), data analysis occurred alongside data collection without a clear-cut separation. We followed a series of iterations between data gathering and analysis (35). Following inductive thematic analysis (37), we engaged in continuous reading and discussions of emerging themes and concepts regarding activities and experiences surrounding the development, implementation and use of the standard proprietary software. We interlaced the inductive analysis with follow-up interactions with participants for clarification on our emerging findings (35). We also presented our interim findings to selected participants at the national, regional, district and hospital levels. Feedback from such interactions helped to verify the plausibility of our findings. We ended the analysis when we felt that saturation point (35) where further analysis yields no more new findings had been reached. The resultant themes were then used to structure the research findings presented in the next section.

4. Case Study Findings

The findings present Ghana's experience with standard proprietary software called District Health Information Management Software (DHIMS). The presentation is structured according to experiences before, during and after the development and of the software.

4.1. Before the standard proprietary software

In 1968, Ghana established the National Centre for Health Statistics (NCHS) to collate aggregate data from hospitals across the country and report to the NHS for policy monitoring and control. Figure 2 shows the reporting structure between the hospitals and the NCHS.

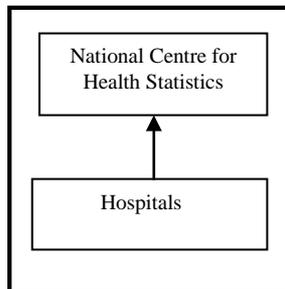


Figure 2. Reporting structure between hospitals and the National Centre for Health Statistics

Because the NCHS was centralized at the national capital, Accra, it found it difficult to collate data from hospitals across the country. Moreover, data from some of the hospitals were either incomplete or inaccurate. Such anomalies caused delays in the NCHS's reporting to the NHS. In the 1980s, the NHS decentralized the HCHS by establishing regional centres. Figure 3 shows the new reporting structure after the decentralization.

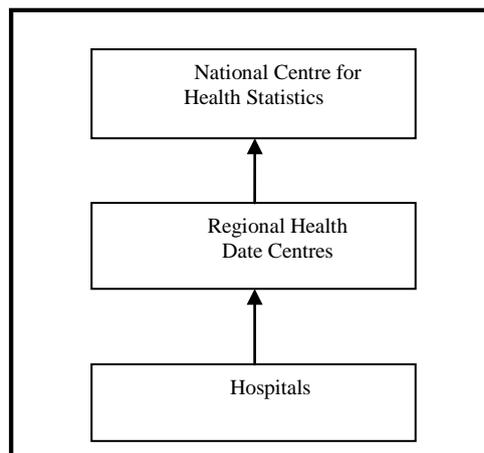


Figure 3. Decentralized region-based reporting structure

The HIS in operation at the time was manual. The hospitals used paper-based forms to compile data and report monthly to the regional centres. Despite the decentralization, the HIS continued to face challenges, including limited information officers as well as inaccurate, incomplete and delayed reporting from the hospitals to the regional centres to the national level. Other challenges included managing and tracking increasing volumes of paper-based forms as well as missing and misfiling of reports. The manual system also caused errors in aggregating and reporting of data at various levels. One regional information officer described the problem with the manual system as follows:

Problems with the manual system led to GHS (Ghana Health Service) inability to achieve its objective of producing and managing health information to support management decision making.

In 1994, the NCHS was transformed into national information centre (NHIC) while the regional centres became regional information centres (RHICs). The NHIC and the RHICs were subsequently computerized to use Microsoft Excel Spreadsheet for data capturing and reporting. Despite the use of Excel at the national and regional centres, there were still challenges of delays as well as inaccurate and incomplete reporting. The director of NHIC summarized the challenges as follows:

Service providers and health administrators had to spend excessive time dealing with a growing number of data collection formats, poor data quality, lack of data analysis, and unusable information.

In 2001, the NHS transformed the sector and established the national health information system (NHIS), regional health information systems (RHIS) and district health information systems (DHISs) and their reporting structure as shown in Figure 4.

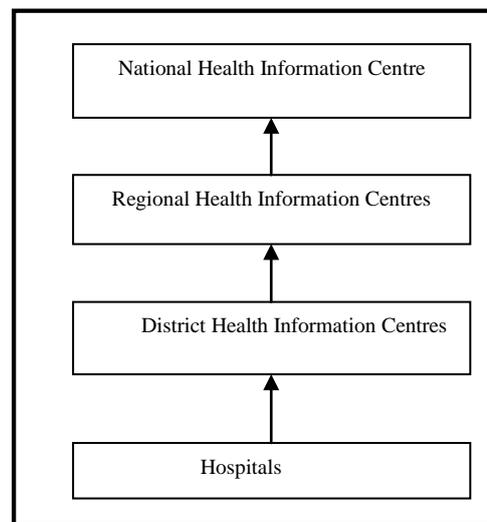


Figure 4. Decentralized district-based reporting structure

The use of the Excel spreadsheet offered much flexibility for the RHICs and DHICs. An officer in one of the RHICs described this as follows:

The main advantage of the excel format was that it was flexible. You could manipulate the data the way you want to suit your regional health information needs.

With such flexibility, reports from the lower levels lacked uniformity. The DHICs and RHICs used varied formats and indicators. The non standard reporting became a challenge for the NHS. One national information officer described the problem as follows:

Reports from the regions did not follow uniform format. Each region was reporting based on their own formats, indicators and level of details. The National Health Service therefore decided to standardize data capturing and reporting across all levels.

In 2003, the NHS decided to replace the spreadsheet with standard proprietary software for use across the levels to address the non standardization problem.

4.2. Development and implementation of the proprietary software

In 2004, The NHS commissioned a project to develop the standard software called the District Health Information Management Software (DHIMS). A commercial software firm was contracted to develop the DHIMS. A project team was formed, comprising the developer as well as IT staff and employees from the national level, without active involvement of users from the regional, district and hospital levels.

At the requirements analysis phase, it was found that as many as 38 different reporting formats and varied indicators and data elements were in use across various levels. DHIMS was therefore expected to standardize reporting formats, indicators and data elements across hospitals, districts, regions and the national level. After analyzing the varied formats, the team designed standard input forms, data elements and indicators for the DHIMS.

DHIMS was developed as a standard proprietary software. The database design, input design, and output design were all based on Microsoft Access. The coding and compilation were based on Visual Basic for Application (VBA). An officer at the national level commented on the standardized design and lack of flexibility of DHIMS as follows:

DHIMS [the software] was designed to be used across the facility, district, regional and national level with no room for extension or modification during use.

In 2006, DHIMS was piloted in 20 districts (2 from each region). Selected officers were trained to train users at the lower levels. In 2007, DHIMS was rolled out for use at the district, regional and hospital levels. The scope of the implementation did not include the sub-districts and vertical programmes. The reporting structure remained the same in Figure 4 above. After the implementation, the hospitals use DHIMS to capture periodic data and submit printed reports to the DHSs, which in turn aggregate the data and submit printed reports to the RHISs, which also aggregate and submit printed reports to the NHIS.

4.3. Post-implementation experience

DHIMS has been in use since 2008. Since then, the post-implementation experiences have been mixed. On the positive side, it has succeeded in creating standardized environment for data capturing and reporting. According to reports from some of the regions, there has been an increase in the frequency and the number of hospitals and districts that submit reports. Delays on the part of the districts and the hospitals have also reduced. The software has also helped to improve monitoring and decision making at various levels. A report from one of the regions points to some of the benefits as follows:

The introduction of the District Health Information Management System (DHIMS) software has helped a lot as it is being used at the districts as the tool for consolidating and reporting on the sector indicators despite the challenges faced by the DHMIS software.

(2009 Half-Year Performance Review Report—Upper East Region, P. 1)

On the negative side, the major problems identified with DHIMS at the lower levels include: low sense of ownership and inflexibility. As a result the software fails to meet custom needs of users at the lower level especially at the hospital and district levels. A hospital administrator complained as follows:

DHIMS does not compute bed utilization statistics such as average length of stay, turnover interval and percentage occupancy which are important indicators for facility level decision-making.

A regional health information officer also compared the DHIMS with the spreadsheet application and complained as follows:

The Excel was flexible. You could manipulate the data the way you want to suit your information needs, but as for DHIMS, you cannot do anything about it. No one can do anything to it.

Due to the low sense of ownership, most users at the hospital and district level view DHIMS as mandatory software meant to meet the information needs of just the national level and not that of the lower levels. They questioned the naming of the software, arguing that if it is about districts, why was it designed to meet the needs of the national level and not that of the districts?

DHIMS also lacks capability for interoperability. It has been difficult to integrate it with various hospital information systems. As result, hospitals manually extract data from their systems to re-key into the DHIMS. The software is also limited in validation controls. Data validation is usually done manually at various levels as noted in one of the report from the regions:

District Health Information Officers were invited to the Regional Health Directorate to [manually] validate their data on the DHIMS and clean it before sending it to the national

level. (2010 Regional Health Directorate, Volta Region, P. 11)

Another challenge is limitations for extendibility or integration with other areas such as vertical programmes or community health services. This has promoted disparate HISs such as the use of MOTTECH (mobile technology for community health), which is not integrated with the DHIMS. The Malaria Control Programme also uses a spreadsheet application that is not integrated to the DHIMS. As one of the regional reports points out:

*This [DHIMS] software is currently encountering some defects of not being able to pick the malaria components of the returns in some districts/municipalities. An excel data capturing template is used as a backup.
(Regional Health Directorate Report—Upper East, April 2009)*

Since 2011, there have been plans to migrate to Web and FOSS-based version of DHIMS, but this is yet to materialize.

5. Analysis and Discussion

The purpose of this study has been to understand a developing country's experience with HIS based on standard proprietary software compared with that of FOSS in other developing countries. The research question concerned why and how a developing country standardized its HIS with proprietary software and the consequences thereof. This section presents the analyses and discussion of the findings in relation to four key issues: standardization and varied information needs, top-down versus bottom-up participatory development, extendability and interoperability and lessons for other developing countries.

5.1. Standardization and varied information needs

The findings show that the NHS adopted the standard proprietary software to create a uniform environment for data capturing and reporting across all the levels in the HIS hierarchy. Before this, the district and regional levels depended on spreadsheet applications that were flexible to meet their varied, custom and dynamic information needs. After the introduction of the standard proprietary software, these lower levels lost such flexibility. Thus, although the standard system succeeded in uniformity objective it tended to meet the standard information needs of the national level but failed to meet the varied information needs for the lower levels.

Within the developing country HIS literature, the tendency to support the standard information needs of only the national needs at the expense of the varied needs at the lower levels has been well criticized (7, 10, 26). Ghana's experience suggests that the use of standard proprietary software HIS has a high tendency to turn the lower levels into data sources and not information users. This however defeats the purpose of health systems and HIS decentralization (5, 8, 10). Experiences from South Africa and other

developing countries however show the challenge of providing standard information needs of the national level and varied information needs of the lower levels at the same time can be met under HIS based on FOSS (7, 10).

5.2. Top-down versus bottom-up participatory development

The findings also show that the standard proprietary software was developed under a top-down approach without active participation of users from the regional and district levels. As a result their requirements were not well captured. The software therefore resulted in capturing the information needs of the national level and not that of the lower levels. Later attempts to customize the software to meet varied information needs at the lower level became difficult due to the standardized proprietary and closed source nature of the software.

Again, experiences from South Africa suggest that bottom-up participatory approach with active involvement of users from all levels including the districts contributed to the success of their DHIS based on FOSS (9, 18). Contrary to Ghana's top-down approach, South Africa's bottom-up participatory approach involving users from the lower levels (11) ensured that the system met their needs as well as that of the national level (10, 22, 38). Comparing the two experiences suggest that in developing HIS, bottom-up participatory approach involving users from all levels is more effective than top-down non-participatory approach at meeting information needs of both the national and the lower levels.

5.3. Extendability and interoperability

The research findings show that the standard proprietary software lacked capability for extension into other areas beyond the original scope or for interoperability to integrate with other applications. Again, the standardized proprietary and closed source nature of the software has made it difficult for it to be extended to areas beyond the original hierarchical reporting structure—hospitals to districts to regions and to the national level. The NHS has not been able to extend it to the sub-district/community level or various vertical programmes. Also, due to lack of support of interoperability, the software is not able to integrate with other health related applications such as hospital information systems or those used by vertical programmes and community health services.

Systems integration is an essential requirement for an effective HIS in a decentralized environment (5, 20). In the developing country HIS literature, lack of system integration through extendability and interoperability has identified and criticized as the reason for the existence of disparate systems and parallel reporting (7, 16, 20, 26). However, system integration through extendability and interoperability are necessary requirements for developing country HIS to overcome data redundancy, disparate systems and parallel reporting (21). Experiences in the literature suggest that HIS based on FOSS offers the necessary capability to support extendability and interoperability of HIS in developing country environments (7, 11, 26, 39).

5.4. Lessons for other developing countries

The analyses and discussion from this study based on the findings offers other developing countries the opportunity to learn from experiences with HIS based on standard proprietary software compared with that based on FOSS as document in the literature. Ghana's experience demonstrates attempt to create a uniform HIS environment for data capturing and reporting. As a result, the country standardized reporting formats, forms and data elements. It also followed top-down development approach that concentrated mainly on the needs of the national level without active involvement of users at the lower level. On the other hand, the literature points to the experiences of South Africa and other developing countries that have pursued HIS based on FOSS and bottom-up participatory approach.

A comparison of the two experiences show that the approach based on FOSS and participatory development is more effective at supporting the information needs of various levels in the HIS hierarchy due to flexible, interoperable and extendable capability built into the system. However, the experience based on standard proprietary software and top-down non participatory approach tended to meet only the needs of the national level and not that of the lower levels. Therefore as developing countries follow decentralization of health systems as recommended by WHO, HIS based on participatory development offers them a better opportunity to achieve their aim that what standard proprietary software based on top-down development offers. However, given the limited computer skills in various developing countries, especially at the lower levels(26), developing countries are advised to invest in training to provide computer skills at that level to support bottom-up participatory development (3).

6. Conclusion

This study investigated a developing country's experience with proprietary software based on top-down development to standardize HIS at all levels. The findings show that the standard proprietary software succeeded in meeting uniform information needs at the national level but failed to support heterogeneous information needs at the regional and district levels. It also failed to support integration and interoperability with other software applications. However, experiences from South Africa and other developing countries suggest FOSS-based HIS with bottom-up development provides the necessary flexibility to meet varied information needs at all levels.

The paper contributes to developing country HIS research by offering rich insight into experiences with development and use of standard proprietary software and provides implications for research, practice and policy. For research, the paper calls for multi-level rather than single level focus to better account for inherent complexities and diversity of information needs in developing country HIS. For practice, the study suggests that standard proprietary software based on top-down development may succeed in meeting standard information needs at the national level but fail to meet varied information needs at the regional and district levels. For policy, the paper calls on developing countries intending to standardize their HIS through proprietary software to rather opt for FOSS such as DHIS to avoid problems of rigidity.

The limitation of the study stems from its single country focus. However, it offers lessons for other developing countries on challenges they may encounter in using standard proprietary software for their HIS and why they may have to opt for FOSS. Future studies can focus on experiences with migration from proprietary software to FOSS.

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