

FOSS HIS in Public Health Domain: Case of Design-Reality Gap and Local Improvisation in Global South

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Background and Purpose: Health Information Systems (HIS) are an integral in health reform agendas even in developing countries, although technological and financial limitations found to be the major barriers. Hence, free and open source software (FOSS) plays an enabling role in global south. FOSS HIS are developed based on generalized domain requirements and, FOSS implementations faces challenges of discrepancy between global design and local requirements. This is known as design-reality gap. The disagreement between abstract requirements and local actuality was found to be crucial for the sustainability of HIS, and design and actuality improvisations were coined as remedial measures.

Methods: This comparative case study encompassing empirical experience of introducing FOSS HIS to Sri Lankan public health sector, expects to discuss health managers' awareness of possible design-reality gaps in embarking on FOSS HIS implementation decisions. It also tries to explore to what extent health managers are ready to accept a design-reality gap and to change the business actuality of health organization to accommodate functional restrictions of FOSS HIS. A series of semi-structured interviews and focus group discussions with health programme managers and public health experts were major source of data for this discussion.

Results: It was revealed that the health programme managers were aware of possible design-reality gap in considering FOSS artefact as a HIS implementation candidate. Also, in Sri Lankan context, health managers preferred design improvisation over actuality improvisation with a conservative view towards business process revision.

Conclusions: Abstract functionalities of FOSS HIS required to be extended to suit the business contexts of health programmes. The specific business routines demanded FOSS artefact to be further customized and the level of customization required ranged up to the source code level. Ability to reach consensus over design improvisation was successful than proposing for business process revision.

Keywords: Health Information Systems, Open Source, Requirement Abstraction, Design-Reality Gap, Local Improvisation

1 Introduction

With the current advancements in Information and Communication Technology (ICT), health Information Systems (HIS) has become an integral part of health reform agendas of most of the countries. ICT considers a key enabler in improving healthcare process and achieving health for all [1]. As a result, healthcare organizations around the globe are investing in health information infrastructure despite the validity of the above assertion. However, technological and financial limitations found to be among the major obstacles in introducing health information systems to national health services in developing countries. In this context, free and open source (FOSS) health information systems play an enabling role in global south, providing not only software solutions with no licensing costs, but also contributing to

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local knowledge and technological advancement by ensuring free access to software source code [2]. Open source design and development [3] is seen as empowering strategy in developing country context for coordinating global and local design process [4][5][6].

Due to the wider socio-political motivation of open source software, the design of the FOSS architecture is based on a generalized and abstract end user requirement specifications and global standards [7]. Also, with regards to open source software development, end user requirements are constantly being evolved and elaborated, and as a result the product is never in a finalized state [8]. FOSS artefacts are designed and developed for general use in the sense that the software features can be modified while being used by a wider community. So, the open source developer communities tend to make FOSS HIS non-specific through the process of generification by identifying those universal aspects of the system when addressing diverse user requirements is extremely difficult. Generification is defined as design strategy software developers adhere to when developing a single artefact that fits into the needs of multiple customers [9]. Rather than based on interactions with the user organizations for programme specific requirements, developer tends to design and code applications based on the basic understanding of the user group on abstract understanding of the user organization in general [10]. For this reason, a FOSS HIS software artefact may not fit in to all user requirements of a health programme during the current software release cycle. The possible disagreement with user requirements is a remarkable challenge health manager and administrators have to face in adopting FOSS HIS artefacts compared to bespoke development of HIS according to the requirements of healthcare organizations. This makes it necessary, either the FOSS HIS to be further customized to the specific need of the healthcare organization or to accommodate business process re-engineering to the health programme operations for it to align with the capabilities of the FOSS HIS considered to be implemented.

However, it was argued that the success of a information system implementation is depend on the alignment of the functionality of the information system (IS) and the organizational work routines and business context. Many information system implementations in developing countries have been reported as total or partial failures and reason for failure were attributed to the gap between IS design and the organizational context [11][12]. Health Information Systems are also among the victims of information system failures due to the design – reality mismatch [13]. Failure of understanding the complexity of the clinical work routines and managerial process of health sector in requirement elicitation is a major reason for this design – reality incongruity. Similarly, fragmented donor policies may also aggravate HIS design – reality gap by ignoring organizational context in introducing health information systems [14]. Donor funding is an essential source of support in strengthening national health information architecture, although there could be institutional, technological, economic and political factors operational in externally funded information technology transfer initiatives [15].

Theoretically based on the argument of HIS design-reality gap and possibility of local improvisation [12][13], this paper analyses the empirical findings of three selected cases of HIS implementation attempts in Sri Lankan context. The open source HIS, District Health Information System (DHIS2) [16] was the focus of these HIS implementation attempted in two vertical health programmes and the empirical findings believed to help in understanding health programme managers' perception of the design – reality gap in FOSS HIS implementations and to identify their preference of different local improvisation options and approaches.

2 Materials and methods

2.1 Theoretical Underpinning

Free and open source software promotes local technological development by having access to the source code of the software artefact. FOSS helps in developing country perspective by helping to set up an information economy, advancing knowledge more quickly and avoiding being hostage to proprietary software [2]. Similar benefits of FOSS available to the healthcare domain as well. Specially, vendor independence through the availability of source code provides reduced total cost of ownership, reduced cost of maintenance and competitive cost for software adaptation and customization. Also, FOSS HIS provides flexibility in end user training and reduction of the risk of losing legacy data when migrating to a new software version or new solution [17]. The distributed development of FOSS enables more user participation and it has been identified as an important development in FOSS HIS to absorb domain

concepts successfully. Generification and abstraction are common practices in open source development process [9]. In the DHIS2 developer community as well, generification and abstraction was the strategy for absorbing local innovation to the global design through participation and network of action [18][19].

HIS implementation attempts sometimes ends up in a failure and the success or failure of a HIS adoption is theorised as not merely a technical matter. The HIS success has been described as the synergy between the information system, the primary (patient or community care) work process as well as the secondary (management and support) work process [20]. Social and professional culture of healthcare organization, complexity of routine care and managerial process and dissonance between the expectations of the HIS commissioner, the FOSS developer or the supplier and the user of the system have been described as major reasons for HIS acceptance or rejection by a healthcare organization [21]. Various attempts have been taken to theorize reasons for HIS failures and, design-reality gap is a well-accepted among those [22].

Design – reality gap consists of six major dimensions of incongruity between IS design and domain context. It portrayed as the temporal and systemic contingency between the current system (political actuality) and the expected future system (rational design) through organizational changes induced by the adopted information system [13]. The actuality and the design has been described under, information; technology; process; objectives and values; staffing and skills, management systems and structures; and other processes. As summarised in **Table 1**, it was attempted to highlight incompatibilities between the rational design and political actuality [12].

Table 1. The difference between the rational design and political actuality

Dimension	Rational Design	Political Actuality
Information	Standardized, formal, quantitative information	Contingent, informal, qualitative information
Technology	Simple enabling mechanism	Complex, value-laden entity
Process	Stable, straight forward and formal	Flexible, complex, constrained and often informal
Objectives and values	Formal and organizational	Multiple, informal, personal
Staffing and skills	Staff viewed as rational beings	Staff viewed as political beings
Management systems and Structures	Emphasis on formal, objective processes and structures	Emphasis on informal, subjective processes and structures
Other resources	Used to achieve organizational objectives	Used to achieve personal objectives

In the context of healthcare domain and health information systems, the rationality has a medical component as well. The medical rationality has been described as “When medical information is seen to play a central role in HIS, those information systems are therefore themselves likely to be conceived according to an objective and rational model” [13]. The design – reality gap has been debated in the context of FOSS HIS as well and there, the controversies between the sponsor and the FOSS developer; the global developer and the local developer; and local developer and local user has been identified with regards to various FOSS HIS implementations [23].

It is easy to embed rational design in software development, but it is nearly impossible to embed political rationality to an IS design with the requirement abstraction. Based on the developers' understanding of the medical domain, generification and abstraction of user requirements and local user expectations and programme objectives, the design - reality gap could be identified with regards to DHIS2 design and implementations as well [24]. The design – reality gap may increase during implementation and operations. The local improvisation is coined as a remedial measure to this phenomenon [12]. Local improvisations are situated actions affected by and affecting the context of their execution. There are two broader categories of local improvisation as follows.

- Actuality improvisation – changing the local actuality (business process and context) to make it closer to IS design.
- Design improvisation – changing the IS design to make it closer to domain concepts and user actuality.

2.2 Research Design

FOSS HISs are results of distributed development based on generification and abstraction of functional requirements. It was argued that the most important role of the IS in the organization is only discovered during the implementation process, hence there is a possibility of an incompatibility between global design and local reality (actuality) in the implementation phase of a FOSS HIS. The ITPOSMO framework [12] suggests design improvisation or actuality improvisation as means to reduce the design-reality gap and to improve the success and acceptance of HIS. The improvisation approach has been practised in many HIS implementations throughout the world [25]. However, authors' empirical experience suggested that in a well-established national level healthcare programs, persuading health managers for actuality improvisation is not a successful strategy in introducing FOSS HIS to health sector.

With the aim of contributing to the academic discourse of HIS design – reality gap, following research questions were formulated.

- Whether health managers are aware of possible design – reality gap in embarking on FOSS HIS implementation decisions?
- To what extent health managers are ready to accept a design – reality gap and to change the business actuality of health organization to accommodate functional limitations of FOSS HIS (actuality improvisation over design improvisation)?

To investigate the above research questions a comparative case study covering two vertical health programmes in Sri Lanka was designed. The three selected cases were based on the empirical findings of attempting to implement FOSS public health information system, District Health Information System (DHIS2). The cases were carefully selected to cover a successful attempt, a partially successful attempt and an unsuccessful attempt in introducing DHIS2 to national health system.

In the data collection process, multi-method approach [26] was adopted employing with several data collection methods. Participant observation, semi-structured interviews and focus group discussions with FOSS implementers, health programme managers, public health experts and other technical partners were conducted and data from informal meetings and relevant document analysis were also gathered during the study process. The two vertical health programmes studied was Family Health Bureau (FHB) and National Programme of Tuberculosis Control and Chest Diseases (NPTCCD) in Sri Lanka [27]. Two HIS implementation attempts were considered in FHB scope, for *National Maternal and Child Health Information System* and *National Foeto-Infant Mortality Surveillance System*. Within the NPTCCD, DHIS2 was attempted for *Integrated Electronic Disease Registry for Tuberculosis and Chest Diseases*.

Case 1 - National Maternal and Child Health Information System: The National Maternal and Child Health Information System was the computerization attempt of existing paper based National Maternal and Child Health records [30] which collect data from Medical Officer of Health (MOH) areas. Data collection is being done by Public Health Midwives (PHM) attached to each MOH are using PHM's Monthly Record and will be aggregated to Maternal and Child Health Return and Quarterly MCH Clinical Return under the supervision of Medical Officer of Health. The data will then be sent to the FHB for further analysis. The HIS implementation attempt was spanned from October 2011 to April 2012. After piloting in few MOH areas, FHB requested to halted DHIS2 implementation until institutional decision is made to implement a national HIS to cover all public health data managed under the FHB.

Case 2 - Integrated Electronic Disease Registry for Tuberculosis and Chest Diseases: Integrated electronic registry for Tuberculosis, Asthma and Chronic Obstructive Pulmonary Disease (COPD) was a long felt need of The National Programme of Tuberculosis Control and Chest Diseases (NPTCCD) of Sri Lanka. DHIS2 tracker was identified as a potential tool for computerising the respiratory diseases registries and aggregated patient information. With the success of piloting in early 2013, NPTCCD decided to implement the system to collect data from selected peripheral chest clinics throughout the island and to customize and evaluate DHIS2 to replace existing HIS for Tuberculosis registry.

Case 3 - National Foeto-Infant Mortality Surveillance System: National Foeto-Infant Mortality Surveillance system was suggested to strengthen the foetal and infant death investigation process of the

FHB. The data related to foetal and infant deaths were supposed to gather from hospitals through heads of the institution and from MOH areas through Medical Officers of Health. HIS supposed to generate summaries of foetal and infant deaths to monthly perinatal meetings headed by the Medical Officer – Maternal and Child Health of the region. DHIS2 was suggested to customise for this purpose and evaluated in early 2013. Unfortunately it was decided that DHIS2 was not capable to fulfil the needs of the Foeto-Infant Morality Surveillance programme.

The semi-structured interviews and focus groups were selected for gathering the qualitative data that will provide insight into the health managers' perception of the end user requirements and the existing functionalities of the DHIS2 software release. The structure of these interviews was mainly based on the software requirement specifications (SRS) prepared for each pilot project. Unit of observation of the study was the organization and this posed a challenge of identifying key-respondents while collecting organizational level data. It was assumed that the perception of health management in vertical health programmes reflect the collective perspective of the health programme and as a result, the views of top managers could be held as reliable source of organizational-level data [28]. So, the opinion of top level administrators those who are able to recognize and assess the strategy within the organization boundaries weighted more in describing the data extracted from interviews, focus group discussions and other communications. A qualitative data analysis was performed with post data collection reduction [29].

3 Results

The health managers apprehended the deviations of current DHIS2 features from the software requirement specification prepared for each HIS implementations to variable degrees based on the business context and operational needs of the health programmes considered. However, they were not dejected by the mere fact of the presence of a design-reality gap in FOSS HIS. However, in general they were hesitant to revise the business process, data elements or indicators for it to be more favourable for the existing capabilities of the HIS.

The specific findings with regards to the comparison of end user requirements and business process of each health programme and the functionalities of DHIS2 were as follows.

Case 1 - National Maternal and Child Health Information System: The main objectives of introducing HIS in the Maternal and Child Health programme was to improve data quality and timeliness of reporting and the based on PHM's Monthly Record, Maternal and Child Health Return and Quarterly MCH Clinical Return. DHIS2 was equipped with the data quality checks and speed up the aggregation and piping data from periphery to central level. DHIS2 was appreciated for its ability for assisting aggregation of data at PHM level. However, the very same feature was seen as voiding the immediate supervision by Medical Officers of Health form the FHB perspective. By the time DHIS2 was piloted in FHB scope, the role based authentication was not strong in DHIS2. Former was affected in long term acceptance of DHIS2 by FHB, even though the direct supervision of PHMs was not an explicit requirement documented during the requirement analysis phase. DHIS2's ability to conform to national language regulations was also questioned. However, limitations of DHIS2 graphical user interface, DHIS2 branding and usability of report generation was particularly criticised.

Case 2 - Integrated Electronic Disease Registry for Tuberculosis and Chest Diseases: In information management related to the activities of NPTCCD, it was vital for HIS to be able to handle patient centric records as well as information required for monitoring, evaluation and planning. In general, DHIS2 with its Tracker module found to be capable in delivering necessary functionalities. Since DHIS2 Tracker was storing individually identifiable patient data, security and confidentiality of the clinical records were among priority needs. However, the data security provided by the DHIS2 was considered satisfactory by the NPTCCD. DHIS2's ability to capture individual patient records by clinic visits and tracking visits and treatment defaulters were aligned with the programme needs. In NPTCCD as well, graphical user interface and limitations of the usability of report generation was noted. Major drawback highlighted during the piloting was DHIS2's inability to seamlessly integrate aggregate and individual patient records between DHIS2 core and the DHIS2 Tracker module. However, health managers agreed to use manual aggregation of individual records while the necessity of this feature was stressed to the DHIS2 developer

community. Almost all data elements in NPTCCD clinic books were able to capture using DHIS2, except for a diagram used to record findings of pulmonary auscultations. As a temporary measure, programme decided to use text based record for chest auscultations.

Case 3 - National Foeto-Infant Mortality Surveillance System: The most unique requirement of the HIS in national foeto-infant surveillance programme was the ability to side-by-side comparison of foetal and infant death investigation records sent by hospital and MOH office for a death of a particular baby. The proposed system shall be able to compare multiple records of death reports and alert for possible duplicates records. This feature was not among the functionalities of DHIS2. Further, DHIS2 based web forms were not be able to capture data using continuous scales, check boxes etc. and to handle questionnaire specific functionalities, like skip logic and piping. After considering all these facts, health managers decided not to consider DHIS2 as a candidate HIS for proposed national foeto-infant mortality surveillance system.

4 Discussion

The empirical setting Sri Lanka, has a centralized healthcare system with a well-established and time tested paper based record system with a better health indices. Hence the health system is generally conservative in business process revisions and computerizations tend to be seen as a business risk. In general, it was noted that health managers are sensitive to the conflict between generifed requirements which is used to design FOSS HIS and the programme specify functional and non-functional requirements of national health system. It was also noted that health managers engaged in FOSS customizations with the pre-occupied understanding of bespoke software development.

During the study, it was observed that health programme administrators prefer design improvisation (highly customization of HIS, including software code level changes) than actuality improvisation (revising the business process). The graphical user interface changes were very suggestive design improvisation in Sri Lankan context to imply the ownership of the HIS by the particular health programme. Possibility for local improvisation (e.g. locally available software coding support) minimized the tension over design – reality gap in vertical public health programmes considered. Also, design improvisation was more successful approach than actuality improvisation, with the exception of NPTCCD seemed to agree for minor actuality improvisations.

Actuality improvisation was acceptable to health managers to a certain extent. This was evident in the behaviours of NPTCCD in accommodating certain changes in web forms, which is different to paper based forms to overcome the limitation of image manipulation abilities of DHIS2. Also, NPTCCD was more flexible to tolerate DHIS2's inability to integrate aggregate and individual patient records. However, this was not the case in national foeto-infant surveillance project where, still the side-by-side comparison could be performed manually while accommodating certain changes in business process to tolerate limitations of DHIS2 functionalities. It was evident that the health managers are willing to sacrifice optional functional requirements if the mandatory functional requirements are satisfied.

So, in concluding the discussion, it is safe to assume that health managers are willing to accept existing functionalities of FOSS HIS in the presence of a design - reality gap in HIS implementations if the majority of functional requirements are satisfied. It is also necessary for health managers to apprehend the difference of FOSS and bespoke software development principles. Accommodating all data elements in the HIS customization, graphical user interface modification to convey the ownership of the system, facility for role based authentication and role based data visibility and high end data analysis found to be having high priority among the functional requirements. It was safe to assume that to a certain extent, health managers are willing for actuality improvisation, even though they are more comfortable and demanding for design improvisation. So, it was advisable for local FOSS HIS implementation teams to equip with the necessary skills and resources for code level customizations in FOSS HIS piloting projects to improve the acceptance by national health programmes.

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