

## Shaping the Evolution of the Health Information Infrastructure in Zimbabwe

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**Background and Purpose:** This paper describes the implementation process of an integrated health information system within the context of a developing nation. The Ministry of Health and Child Welfare (MOHCW) in Zimbabwe was engaged in migrating legacy paper and desktop based information systems to the District Health Information Software (DHIS2), a web enabled and open source technology. The aim of this paper is to contribute to the development of theory that can be adopted to improve outcomes in such endeavours.

**Methods:** The study is conducted using the Action Research (AR) approach whereby the authors were actively involved in shaping the implementation of the information system. It occurs within the broader context of the Health Information Systems Programme (HISP), where an AR approach, the Networks of Action, has been developed for sustainable interventions in developing nations. The work is also informed by the grounded theory methodology, whereby empirical data was the basis for making a theoretical contribution.

**Results:** An interorganisational network consisting of actors interacting at the administrative level of the public health system plays a central role in determining the trajectory of the health information infrastructure. Collaborative challenges at this level are demonstrated to lead to further fragmentation of the health system thereby increasing the inertia of the installed base. At the user level, numerous strategies to cope with the challenge of supporting the health information system are described. The development of capabilities at this level is shown to be key in increasing the adaptability of the installed base.

**Keywords:** Health Information Systems, Information Networks, Action Research, Developing Nations, Grounded Theory, Integrated Delivery Systems

### 1 Introduction

The health systems in Zimbabwe are constrained due to a shrunken infrastructure and increased information needs. The nation experienced major socio-economic and political vicissitudes in the period spanning 1998 to 2008. This eroded the significant gains that had been made in health information infrastructure strengthening which can be traced back to independence in 1980, with transformatory activities being recorded from as early as 1982 and computerisation in 1985 [1]-[3] (as referenced in [4]). However, the nation witnessed resurgence from 2009 to 2013, during a period when a unity government was in place. In this time frame, the Ministry of Health and Child Welfare (MOHCW), in partnership with stakeholders, started to migrate its information from decentralised, paper, and standalone software systems to an integrated, centralised, and web based system utilising the District Health Information Software (DHIS2).

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A rallying point for stakeholders within the discourse on HIS strengthening was, and continues to be, the prevalence of fragmented systems and the need for standardisation [5]. In order to direct scarce resources to critical and high impact areas, program specific systems flourished in many developing nations [5]. These were isolated from the broader health systems leading to their characterisation as vertical, siloed and fragmented [6]. Programs, such as those focusing on AIDS and TB, had their own information systems and funding arrangements, which contrasted with the poor condition of the surrounding infrastructure. The flow of information across the vertical organisational boundaries was therefore problematic. As information needs continued to increase, and resources decrease, many nations have chosen to develop 'shared' information infrastructures, thereby the call to integration of disparate systems [5][7].

Advances recorded in the internet infrastructure within many developing countries are lauded as an opportunity to achieve health system integration [8]. Projects aimed at replacing the paper-based and standalone systems with centralised internet based technologies continue in numerous nations, including Zimbabwe [5][9][10]. This network revolution within developing nations is also supported by the high proliferation rates of wireless internet access[11]. Health systems in developing nations seek to leverage these network infrastructural developments to achieve better healthcare for citizens and to improve the working conditions for public servants. Furthermore, as will be demonstrated in this study, health systems strengthening projects lead infrastructure development efforts within the domain. The domain consisting of a multiplicity of stakeholders such as policy makers, donor organisations, researchers, civil servants, developers and private interests [12]. The evolutionary path of health information systems is therefore determined by events that are not only specific to the implemented technologies but also originate in these organisational structures and the corresponding interactions [5]. The strengthening of the health information systems in developing nations is therefore considered as a complex socio-technical concern requiring systems thinking approaches to resolve [13]. The large scale nature of health systems development programs also entails their characterisation as information infrastructures [14]. This differentiates them from the smaller information systems projects that have fewer 'moving parts' and are limited in their temporal and spatial reach.

We will now continue by providing a review of information infrastructures literature for comparative purposes, paying attention to the different approaches that actors engage to resolve their concerns within the evolving socio-technical system. The methodological approach adopted in the study is given in the materials and methods section, after which we provide an analytical description of the evolution of the information infrastructure in the results section. Finally we conclude by discussing the practical and theoretical contribution from the study.

## 1.1 Information Infrastructure

An Information Infrastructure has been defined as "a shared, open, heterogeneous and evolving socio-technical system consisting of a set of IT capabilities and their user, operations and design communities" ([15], P. 4). Typical information infrastructures are the internet [15], health information systems [14][16], public sector ICT architectures [7], and online collaborative environments [17]. These are to varying degrees, shared, open and contain numerous differentiated and interconnected parts and are therefore heterogeneous. Furthermore, they are constituted of IT capabilities distributed among their users, operations personnel and designers. A key to understanding the evolution of infrastructures is the installed base [7]. An installed base is the pre-existing and current state of a system and can be discovered and experienced as resistance or inertia during periods of change [15]. This shows that an information infrastructure is relational to the people and practices which it supports and it can not be known without them [18][19].

The evolutionary trajectory of an information infrastructure emerges from the resolution of the tension of whether a chosen path can initially accommodate the needs of an installed base on one hand, and whether it can be adapted to the needs of a growing user base on the other [15][16][20][21]. Tension arises due to the multiplicity of actors engaged in infrastructure development activities since what is often posited as the best design by others often falls short in the context of implementation, requiring innovation to appropriate to local contexts [22]. These issues are more pertinent in the "global village" where initiatives designed abroad find themselves in local settings, a process which has been called glocalisation [23]. The resolution of the tension between the local and the global is a key process for the

emergence of infrastructure [19]. A tension has also been identified between the technical and social view of information infrastructures [19]. It is when these tensions are resolved that an information infrastructure emerges [12][19].

### **Shaping the Evolution of Information Infrastructures.**

Of critical importance in the area of health systems development, is shaping the evolutionary trajectory of an information infrastructure [12][15][24]. This is important given that the evolution of infrastructures is intrinsically path dependent [15]. Once a decision is made to adopt specific systems and the installed base is developed, it becomes difficult to reverse the unintended side effects due to potential lock-ins [24]. An example that is often cited is that concerning the adoption of the QWERTY keyboard, which has become a de facto standard. Even if the Dvorak format of keyboard is espoused to be more efficient, it remains difficult to implement under current conditions due to the dominance of the QWERTY layout [25]. The paradox is that path dependence is also desirable due to the security of continuity it provides to organisational life [26]. Due to these seemingly conflicting attributes, an information infrastructure is therefore considered as a complex phenomenon. It grapples with intended goals and emergent unexpected consequences [26]. These shape its actual trajectory in practice and research suggests that the result is a high rate of unmet expectations [19][27]. To tackle this reality, studies on the suitable approaches that can be adopted to harness complex environments are widespread in the information systems discipline [12][28].

## **1.2 Macro Intervention Strategies**

A primary approach for shaping public sector information infrastructures is standardisation. This entails bringing together stakeholders from government, the private sector, civil society, international agencies and research institutions to collaborate in the standardisation process [7]. These agencies have been recognised as prominent in shaping the evolution of ICT infrastructure in developing nations [12]. However, their engagement has also been recognised as problematic since the domain of their operation has a political character [29]. For instance in a study of health systems in Guatemala, Silva and Hirschheim [30] demonstrate how a health systems program was terminated as soon as one political party lost elections in the nation. The reason provided in this study (*ibid*) was that the health program had failed to alter the deep structures, that is the political culture that had become entrenched due to agreements made to end a civil war that had lasted for more than three decades. While such a case is unique, it remains that organisational networks are scenes where the negotiation of power occurs and infrastructural decisions are made [29].

## **1.3 Micro Intervention Strategies**

While decision making is typically a concern for those in the realms of management, users and developers of systems adapt numerous strategies to cope with their corresponding challenges [22]. Concepts that have emerged in understanding how activities at this level shape infrastructure are bricolage, improvisation and articulation work [16][22]. Bricolage has been aptly defined as “the ways that individuals and groups borrow from existing cultural forms and meanings to create new uses, meanings and identities” [31]. Improvisation is a related concept that emphasises the momentary and timely aspects of reacting to emergent challenges [22]. Articulation work however, is differentiated from the concepts above in that it does not presume that that actors have “much control to stabilise the meanings and purposes of technologies” [31].

A characteristic which enables investigation of information infrastructure is that it is invisible except when undergoing design or has broken down [19]. When breakdown of infrastructure is imminent, articulation work ensues to cope. Articulation work has been defined as the work that enables other work [32]. Articulation work is therefore considered as infrastructure work [19]. There are different forms in which articulation work can be observed during breakdown such as ‘making do’, ‘workarounds’ and ‘institutional rearrangements’ [32]. The activities that ensue when infrastructure breaks down are occasions for innovation [16], and are seen by Ciborra [22] as important considerations in the formulation of strategies to develop information systems.

## 2 Materials and methods

The study was primarily conducted within the action research approach which is the dominant method within the global Health Information Systems Programme (HISP). There are a number of action research approaches identified in IS literature [33] and the specific method chosen in this study is informed by the networks of action approach [21]. It emphasises the importance of collaborating with a diverse range of stakeholders in different organisations in order to ensure the sustainability of an intervention [21]. The network of action approach does not prescribe procedures for data collection and analysis; hence a complementary method is appropriate to improve on the rigor of the study. To address this, the grounded theory method (GTM) was utilised. It is an inductive method which allows for the consideration of various data sources for the purpose of constructing substantive theory [34]. It offers a range of analytical procedures such as open coding, selective coding, theoretical coding and constant comparison [35]. The combination of the two methods to understand practice is not novel in the Information Systems discipline and this mixed approach has been named 'grounded action research' [34][36]. The procedures of open coding, selective coding and theoretical coding were utilised on the data collected during the action research.

The data utilised in the study was obtained from 8 qualitative interviews, 7 meetings with stakeholders, direct observation, project documents and by participating in conducting systems analysis. Field notes were the dominant method of capturing events. The participants included health information officers, information managers, program heads, donor agents and software developers. Constant comparative analysis was conducted on the data from 2 field work visits of 4-5 weeks each. Coding of data was conducted utilising nVivo software. The broad aim of the study was to discover the core concerns shaping the evolution of the information infrastructure understand how they are resolved by actors and develop theory on how they can be leveraged to improve outcomes. Categories generated through open coding were compared with other related codes and with concepts found in literature. Care was taken not to force concepts onto the data, and the principle of emergence of concepts from data was adhered to. Theoretical sensitivity was developed through a continuing literature review. The study is epistemologically critical and interpretive [37]. It is critical as it seeks to develop appropriate ideas to intervene to enable change and interpretive in that the authors acknowledge their involvement is implicated in the evolution of the information infrastructure.

## 3 Results

The MOHCW in Zimbabwe made significant progress in transforming its health information infrastructure enabled by a decision to change the decentralised paper and standalone software based information system to one that is centralised, integrated and web based. The health information system is organised into four levels, constituting the health facility, district, provincial and the national levels. The system had been based on a range of paper based registers implemented in all health facilities and collated on a monthly basis for reporting to the district level. At the district, the aggregate figures from the health facilities were recorded into a standalone 'Microsoft Access' based technology called DHIS 1.4. These were further aggregated upwards to the provincial and national levels through sending data files by email to the respective information officers. The entire process of sending data from the facility level up to the national level has been known to take up to a month, therefore affecting the timeliness of reporting. To circumvent this challenge, a weekly surveillance system was implemented using mobile technology, where all health facilities were provided with mobile devices as tools to report a limited amount of time critical health information. However, the MOHCW took a further step to implement a web based reporting system called DHIS2 in order to tackle the issue of fragmentation.

### 3.1 Sacrificing and Improvising

A key issue observed in Zimbabwe was the challenge of internet accessibility, from the level of district and below. Health workers from two rural hospitals and a district office visited within one district had been using wireless dongles which required that they performed data entry at midnight when internet access improved. This would be a form of articulation work, and one participant noted that this

“sacrifice” was necessary. Another health worker also noted a challenge in obtaining a username and password to access the laptop for data entry into the system. This had occurred due to the fact that the health worker who had been trained for data entry into the system had since left the facility. Improvised in-house training had been arranged by nurses at the rural hospital to fill the gap. However, the laptop was lying idle due to a failure to obtain access privileges. With internet accessibility such a problem could have been resolved through remote desktop tools. This demonstrates the need to develop IT capabilities, so that such issues can be resolved locally. As noted by a manager: *“most of our personnel on the ground, that is the district health information officers ... their skills are limited in terms of what they actually know in IT”*. This type of breakdown would require top management support and institutional rearrangement for sustainable repair.

### 3.2 Health System Development Network

The ministry was the key decision making body for the health information system intervention, which it implemented through an interorganisational network. A multiplicity of actors had been engaged in the development of the health information infrastructure by the MOHCW. At the institutional level, the network was composed of donor organisations, academic institutions, private companies, health programs and consultancies representing local, regional and international interests. These organisations are pivotal in shaping the trajectory of the evolution of the infrastructure by providing financing, technical competencies, and other material and non material resources.

The network is engaged with the ministry in their different capacities, and being part of the installed base contributes to its inertia. Inertia arises due to challenges in collaboration among actors due to a lack of clarity on procedure. As one participant noted: *“you can not jump certain steps ... we can only engage other people to get on board [when] the system is fully running ... inasmuch as technology is ready, policy is not ready so you still have to go back to policy and check what are the policies governing these people?”*. Challenges in collaboration can further fragment interventions on the ground, increasing the work of health workers to keep up with information needs. For instance reporting online can be requested from facilities that have not had access to internet infrastructure, impacting on data quality. In one instance, it was observed that electronic devices that were acquired for acquiring co-ordinates to enable tracking of individual cases of Malaria were highly proprietary and could not be easily programmed to address cross platform needs. Given that the acquisition process had been initiated, it was not possible to reconsider the alternatives. Such issues highlight the importance of improved collaboration among the stakeholders and how the outcomes of the decision making process can increase the inertia of the installed base.

### 3.3 Implementation Strategies

A key strategy used to intervene in the information systems of the MOHCW, is engagement with top management for support. Decision making is centralised in the health ministry, making such engagement crucial for success. A project manager noted that they had earlier tried a bottom up approach and faced challenges. This also suggests that an adaptive strategy is important for a successful intervention. To adhere to formal protocol meant early planning, as noted by a participant: *“getting an IP address took 6 months ... so we had to start early”*. A multi-stakeholder meeting to discuss HIS support could not take place due to concerns raised about protocol. This also showed that power was an issue among implementation partners. There also existed a conflict of interest which increased inertia of the installed base. In an instance, a data manager in one organisation lamented as to how he was failing to get access to information on the latest health facility list, a problem that affected the organisations ability to meet internal reporting deadlines and had been ongoing for months. Access to information in the ministry is centralised, and the level of access by external stakeholders is related to ones positioning in the network. A project head noted the importance of attending to *‘low hanging fruits’* as a strategy for success in this context. A manager also noted the importance of knowing *“where you are going”*, while others lamented slow progress due to collaborative inertia. Information officers interviewed highlighted that, it was not only an issue of power that caused some interventions to flourish over others, it was how they assisted in alleviating concerns of the health worker. A key concern among health workers is the burden of balancing data entry in the numerous registers, and providing patient care on the other. Agencies that required

increased data access and offered no direct incentives to reduce the workload of health workers faced a risk of failing to meet their objectives.

## 4 Discussion

In this study we find that while a bottom up approach to interventions is critical, engagement with the structures where power is negotiated is also important for success. The role of networks in shaping information systems projects in developing nations has been recognised in a study by Njihia and Merali [12] who studies the evolution of ICT provision in Kenya over a period of 42 years. They (ibid) develop a mechanism highlighting that certain changes to systems can lead to stasis or genesis. This supports the finding in this study that activities by actors in interorganisational networks can increase installed base inertia, particularly if they are fragmented, or reduce it through collaborative activity. It also confirms path dependence of information infrastructures, thereby demonstrating the network effects of decisions made by interorganisational network participants. The concept of donor dependence is of crucial importance here, since the activities they undertake can serve to entrench their interests in the installed base. One way that has been suggested to improve outcomes in information infrastructure projects has been to increase heterogeneity of actors in implementation networks, including those with diverse views into the process [15]. This should however be accompanied by the development of policy in order to reduce the advent of opportunistic behaviour [38].

Further work aims to develop the emerging conceptual model and to integrate the findings into the broader literature on information infrastructures. Issues that are of importance to further research include the development of strategies to improve collaboration in interorganisational networks, leveraging the installed base by paying attention to how implemented technology interacts with work practices, and institutionalising adaptive technology appropriation mechanisms. Specific consideration should also be given to the embeddedness of infrastructure in wider society, and the key issues that arise. Studies could do more to clearly demonstrate how the evolutionary trajectory of information infrastructure is located within the wider infrastructure of society. This would entail the development of substantive theories which are faithful to the contexts studied.

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