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# **A critical analysis of the implementation of health information systems for public healthcare service delivery in resource-constrained environments: A South African study**

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**Abstract.** The use of technological solutions is argued to offer quality enhancing efficiencies in the delivery process of healthcare services. For this to be realized certain objectives of these technological solutions have to be achieved. The public health system in South Africa faces various challenges such as poor coordination of most technological solutions therefore fragmented; a lack of interoperability between different systems, haphazard procurement processes and poor information management capabilities. The argument in this study establishes that the causes are not purely logistical but also linked to gaps in the adequacy of the health information systems (HISs) and the implementation process of these technological solutions. A case study strategy, whose empirical home is rural South Africa, was employed using qualitative methodology. Activity Analysis and Development (ActAD) framework was used as a theoretical lens within critical realist paradigm. The study was conducted in a public healthcare facility within a resource constrained environment. Semi-structured interviews was used as data collection method and analysis of data was through narrative and explanatory analyses, employing thematic analysis tool. The paper intends to come up with a framework that can be used to inform the implementation process of HIS(s) across board. With a focus on the context of a divergent national service delivery reality that impacts the right to healthcare service in under-served communities.

**Keywords:** Health information systems, Healthcare service delivery, Resource constrained environments, and underserved contexts.

## **1 Introduction**

Effective healthcare service delivery in the public healthcare sector is built on the back of adequate use of clinical and administration systems implemented in healthcare facilities. Reichertz [1] argues that the most common administrative support functions of these systems include collection, processing, storage and retrieval of data using various innovative Information and communication Technology (ICTs) tools. The healthcare domain incorporates a wide range of technological tools that are

rapidly diversifying in their purposes. These technologies present great opportunities in the transformation of healthcare service delivery process. Readily identifiable opportunities include easy access to integrated real time, relevant administrative and clinical health data and information necessary for adequate service delivery of healthcare and decision making at various government levels [2]. Moreover, improved health outcomes, administrative efficiency, cost effectiveness, or users' experience are also some of the perceived benefits. The significance of these interventions, and their intended beneficial effect on healthcare personnel and health outcomes, it is imperative to ensure that optimal results are achieved, and any unforeseen outcomes identified.

This paper looks at HISs as one of the many technological innovations within the public healthcare domain. HIS is used in this paper to incorporate an all-inclusive range of information and communication technologies interconnected across a health system. Technologies are often viewed as enablers in a healthcare system in improving service provision processes, by aiding institutions to do more with lesser resources, quicker and cost effectively [3, 4]. This point would be ideal for healthcare facilities in resource constrained environments-- *this are contexts that are plagued with shortage of human resource, lack of or limited skills and capabilities to formulate policies and strategies for the development or implementation of novel ideas*. However, the perceived benefits of HISs are only possible to achieve when the implementation and infusion of these systems into the work processes of healthcare personnel are done adequately [5]. This study sought to address the question of *why the existing implementation of HISs in public healthcare facilities is not adequately facilitating provision of care services in resource constrained environments*.

In South Africa, an example of HIS existing in the public healthcare domain is the District Health Information system (DHIS) which was established as a routine system for tracking health service delivery in the public health sector in 1996/97. The system, developed by the Health Information Systems Programme (HISP) was implemented to play a pivotal role in the collection, capturing, storage, analysis and reporting of routine data [6, 7]. Despite the great achievements of the DHIS, increase in the demand for routine information exposed weakness to the system such as poor data quality, dataflow bottlenecks [8] and reporting discrepancies at different levels. A web-based DHIS2 was introduced to mitigate some of the challenges with the earlier version. However, this was only done in one province whilst the rest of the provinces continued with the DHIS.

Many HIS implementations are usually done in a silo ad hoc manner resulting in fragmented systems with limited interoperability and software reuse, and a plethora of small pilots that are often not scalable [9]. This leads to duplication of data and information [10], a high dependency on technical support from external donors and many more challenges. These challenges that are more prevalent at public healthcare facilities in resource constrained environments where data collection is still a significant burden [11]. Resulting to inhibited adequacies as well as analysis and decision making [12, 13].

This paper adopts Damschroder et al [14] concept of implementation broadly summing it up as encompassing the processes involved in the HISs operating

satisfactorily in varied healthcare contexts. This would include analysing healthcare facilities requirements in varied contexts, installation and configuration, customization, running, testing systems integration, user training and making necessary changes to the system.

## 2 Literature Review

### 2.1 Information Systems in Healthcare

Innovations within the health care sector according to [15] and [16] are directed at improving a healthcare system's efficiency and responding more effectively to patients' care needs thus improving health outcomes. The various types of information systems (IS) in this sector are designed to assist healthcare practitioners with managing daily tasks and patients' information in the delivery of care services to a population [17]. They include the following : (i) *Operational and tactical systems* designed to ease the process of classifying information, (ii) *Clinical and administrative systems* designed for managing patient details on an administrative level, (iii) *Subject and task based systems* such as Electronic Medical Records (EMRs) and (iv) *Financial systems* for tracking revenue and managing billing submissions.

The provision and management of the necessary information is highlighted as an essential ingredient to the system of health care governance [18]. Further arguments are that the delivery of care services is highly dependent on information [19], consequently the management and ultimately adequate use of the technology enablers are of paramount importance [20]. Healthcare institutions rely largely on information about the science of care, individual patients, care provided, result of care, as well as its performance to provide, coordinate, and integrate services [21]. According to [22] and [23], HIS emphasises on optimizing and utilizing information to increase efficiency and effectiveness in healthcare institutions. The systems are also designed to integrate data management and use for the improvement of patient healthcare services provision through better management of patient data at all level of implementation [24]. Most health systems around the world still struggle with implementation, and experience major delays in diffusing innovations [25].

### 2.2 Healthcare Information Systems Implementation

The implementation of HIS has been at the forefront in the field of information systems, with literature revealing an on-going debate between the impact of the technical aspects Vis-a`-Vis human behavioral aspects. Authors like Keen and Morton [26] argue that the IS implementation process is an intuitive skill and that the best way to deal with it is to be technically competent. Contrary to Keen and Morton, [27] and [28] argue that implementation process depends on user involvement, how the prototyping of the system is done, the information analysis done on the nature for the implementation and change agents. The later argument on user involvement seems to carry across literature on IS implementation. Involvement of users in the implementa-

tion process is crucial because they can point out where the system could fail. The authors also note other important factors such as top management commitment and training have an effect in the implementation process (ibid). According to [29] the implementation process of IS includes the following four activities; (i) defining the innovation problem and goal setting; (ii) planning activity; (iii) implementation activity; and (iv) use and development activity. The shaping of the planning and implementation process of information systems in the user organization can be seen to be affected by the development mechanism proceeding in two ways: (i) the strategic goal setting and the definition of planning and implementation practices performed by the management, as well as by the planners; and (ii) the user activity [30; 31; 32; 33].

### **3 Methodology**

The study was aligned to qualitative research methodology because of the exploratory and explanatory nature of phenomenon under investigation. The research paradigm aligned to this study was the critical realist's perspective. This is because knowledge is considered socially constructed and through retrodution, it provides causal explanations of actual and empirical evidence. The study adopted the critical realist's ontology as it focuses on the generative mechanisms, causal powers, deep structures and reality of entities [34] which have implications on the healthcare service delivery and the implementation of health information systems.

Both positivism and interpretivism paradigms are argued to suffer from the 'epistemic fallacy' i.e. they reduce statements about reality to statements about human knowledge of that reality. Moreover, the two paradigms assume that what exists is only what we observe and experience. It is on the basis of this that critical realism was chosen for this study. Further, the study adopts the use of critical realism paradigm as a means to gain an in-depth understanding of the relation between HIS implementation and its adequate use in the facilitation of care service delivery for an improved health outcome. Arguments are that critical realism simultaneously confronts the central concern of both the natural and social science regimes. It is on the basis of this reasoning that makes critical realism of particular interest in the study of information systems which bears significant relevance to natural science (due to their application in deeply human context such as organizations). The critical realists' assumptions and feature of realism correspondingly matchup with the theoretical lenses upon which this study is hinged: Activity Analysis and Development (ActAD).

#### **3.1 The use of ActAD framework in this paper**

ActAD framework was employed in this paper as an analytical lens through which the interplay between HIS and the society within which it is implemented is explored. The framework focuses on a work activity and the key features (object, actions, mediation, subject, actors, tools, transformation, rules, and outcome) of the work system are as illustrated in Fig. 1. The work activity portrays an activity as a collective phenomenon with a shared motive which stems from the organizational objectives or

strategic goals. These activities are mediated by mediators such as tools, signs, artefacts, context and conditions. The collective activities involves actions carried out by *actors/subjects* who collectively or individually are directed by rules and norms established by organizations to achieve a shared *motive or goal*. Context, culture, tools and rules also mediate the relationship between subjects and objects as well as amongst the subjects. The delivery of healthcare services through the use of HIS is seen as the key activity object in the framework. The main activities are therefore the interaction between the actors, tools mediators and the actual healthcare delivery process.

The transformation of the object into an *outcome*, renewal, alteration or abortion of the object have a predetermined timeframe in a work activity. This could be because of the failure of the object to achieve a desired outcome, perhaps as a result of contextual inhibitors or mediator tensions. Therefore, [35] argues that a successful interplay between the object from the mediation process and actions result into outcomes, where the objects undergoes a successful *transformation* into an outcome. In Fig. 1, the object-representing a common purpose held by all actors (Dept. Of health, Medical and clinical personnel, nurses and administrators/clerks) in a public healthcare sector is to provide patients with adequate healthcare services. The object is then broken down into different goals, activities and responsibilities for each actor in the system. The goal and related responsibilities of the main actor, the national Department of Health (D.o.H) in South Africa, is to improve patient care by providing and enabling adequate healthcare services provision in public healthcare facilities. One of the main mediators based on the framework, is enabling factors- public healthcare facilities require enabling tools to be able to provide efficient healthcare services.

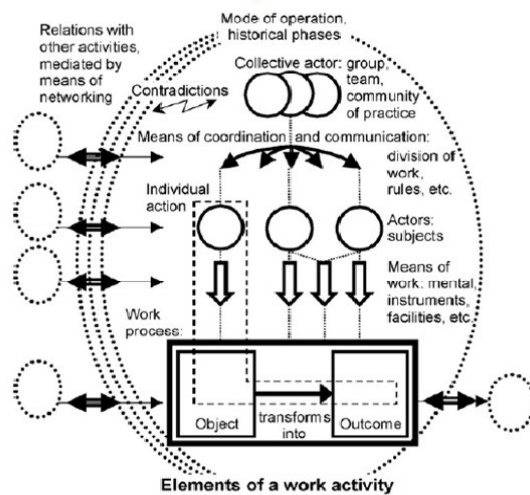


Fig. 1. The ActAD Framework: the structure and relations of a work activity as a systemic entity [37].

The key problem this study sought to address was the perceived gap in the explanation of the failures of the implemented HISs to adequately facilitate healthcare service delivery in public healthcare facilities within a resource constrained environment. The key features of the work system in the conceptualized ActAD framework which draws on from activity theory, was developed to operationalize and contextualize healthcare activities at public healthcare facilities as shown in Fig. 1. From an activity systems based approach, healthcare service delivery process can be analyzed as a service provision with an objective, mediators, actions, mediator tensions, work activity as a transformation and the activity outcomes.

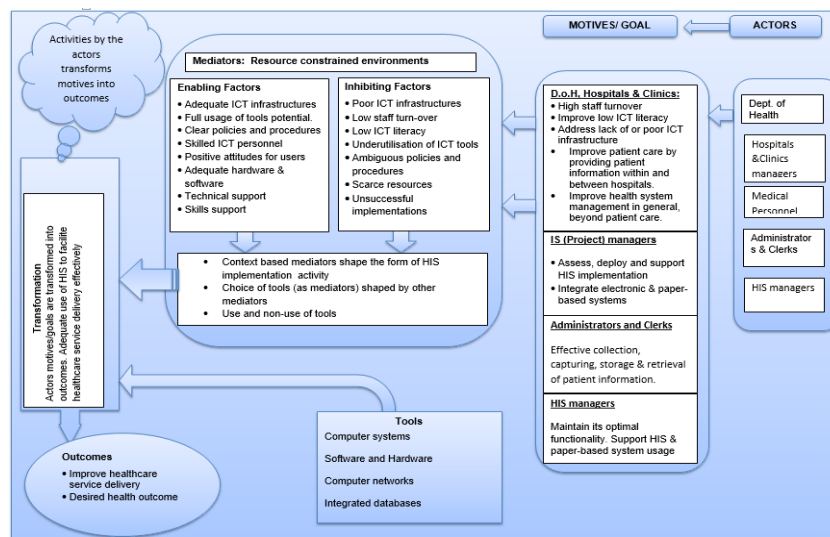


Fig. 1. ActAD analytical framework

### 3.2 Empirical Case

The healthcare facility used in the study is located in the OR Tambo Municipality in the Eastern Cape province of South Africa. Both the municipality and the healthcare facilities bear characteristics of a resource constrained environment. The facilities are government funded and provide tertiary healthcare services to the region. The healthcare facilities are plagued with shortage of clinical staff. The selection criterion of the facilities was based on the availability of health information systems such as the District health information system, patient records management system, laboratory information system and radiological information system.

### 3.3 Data Collection and Sample Size

Data was collected through in-depth open ended semi-structured interviews to gather information about stakeholders' knowledge, experience and, interpretation on the use and implementation of HIS in healthcare facility. Document reviews, observa-

tion and review of the software systems in use were also used as data collection methods. For data analysis, ActAD framework was used as an analytical lens together with thematic and content analysis (for document analysis). A purposive sample was drawn from the provincial Dept. of health, hospital and clinic. The research sample consisted of senior hospital and clinic managers (as they manage the healthcare facilities and are involved in the implementation of various health information systems); clinical and medical staff including nurses (as they are the users of these systems for clinical work to provide services); administrators and clerks (as they use the systems to capture patient details at the entry point); HIS managers and the information systems managers (a representative from the provincial department of health- as they oversee the adoption and implementation of health information systems at healthcare facilities). In Total 21 participants were interviewed over the course of 6 weeks.

### 3.4 Data Analysis and Findings

This section presents the initial data analysis and preliminary findings on the factors of HIS implementation and use in facilitating health care service delivery in public healthcare facilities within resource constrained environments in South Africa's Eastern Cape Province, based on the 21 interviews. The study built the semi-structured interview questions around the ActAD framework, suggesting that healthcare service delivery processes are determined by the interplay between mediators, tools (HIS) and actors. Further questions employed different factors that mediate healthcare service provision in the facilities –dependent variables such as diverse HIS usage or under-utilization and whether the use adequately facilitates the work processes depend on the interplay between the enabling and inhibiting factors. This paper presents the preliminary findings in three themes of investigation: usage of tools, user skills/competencies and functionality (sub-categorised into *system functionality, degree to which the system is used and how the failures affect other functions*). The section draws on Fig. 1 (as an analytical tool) to present the public healthcare service delivery processes as an object activity system.

#### Usage of tools (Health Information Systems)

. Based on the initial findings, there is prevalent evidence of usage of tools in the facility for facilitating health care service delivery in the hospital and clinic. Some of the systems have been in use since the foundation of the hospital. The hospital and clinic section are using a combination of electronic systems such as “*Delta9 (an electronic health patient registration system) (PRT1)*”, *DHIS, Picture Archiving and Communication System (PACS) and Radiology Information System (RIS) (PRT1, PRT2)*. In the laboratory unit of the hospital “...we use electronic gate keeping system (in short we call it EGK) the system is used by the all the doctors to request for patients' laboratory test” (PRT3). The Delta9 system is an electronic system used for patient registration “...at this unit of the hospital (patient registration), we use the system to only capture and store patient biographical details and record the purpose of the visit” (PRT1), “...the patients' record unit also makes use of this system as



*well... and also the revenue department makes use of this department for billing purposes...*” (PRT1). A major contradiction is the usage of paper-based system-healthcare facilities still uses the paper folders to store patient clinical data – which limits the sharing of data by multiple users, as paper files can only be in one point and cannot be used in multiple areas at the same time. “... *although we have these systems here we are still required to record the things we do manually*” (PRT3). Although the electronic system is available the paper based system is still mainly used to store “... *the medical information that the doctors and clinicians have written or things like laboratory reports they have requested on the patient*” (PRT4). The clinics make use of the Primary Healthcare information system (PHCIS) for patient data management and reporting.

### **User Skills/ Competencies**

. The availability and usage of relevant systems in various hospital units reflect a positive development in the findings, however these systems can only add value if their potentials are exploited fully. The analytical framework Fig. 1 suggests that there a need not only for the presence of the mediating enabling factors such as adequate ICT infrastructure and networks, but also the will of the subjects/actors to put their skills into effective use. User competencies in this paper is used as the understanding, literacy and ability to put a system into effective use [36]. For instance, framework the goal of a medical personnel and clerks/administrators is to provide health care services delivery through effective use of tools, rules and processes. For clerks, information systems such as Delta9 and the EGK systems based on the findings are the main tools (and mediators) - to effectively collect, capture, store, share and maintain the integrity and accuracy of patient data/information in the process of delivering healthcare. This same tools are also utilized by medical personnel to efficiently record, share patient diagnoses and prognoses at the facilities. The framework suggests that for the realization of these operational goals to take place depends on the interplay of the adequacy of ICT skilled personnel, relevant frequent training and readily available technical support for the users. The logic here is that unless the users are competent to effectively use the available tools, they cannot put it into use effective use. For instance PRT 4 indicates that “*sometimes when the clerks enter the doctor’s request into the system you find that they make mistakes that they should not be making like capturing duplicate requests or capturing lab requests that are not made by doctors*”.

### **Functionality**

. The analytical framework emphasises the significance of relevant systems with continuous availability and uninterrupted functionality. Findings reveal that a reliable systems improve confidence in the pursuit of user’s operational objectives. Also revealed is that restricted infrastructure capacity, inadequate coordination of networked systems and restricted technical support are the negative mediators (inhibitors) of HIS usage by users in the hospital. Citing resource limitations such as

*“...disjointed systems, interruptions of network, technical support for the users...”*  
PRT5 complains that they have a tendency of interrupting the provision of care.

#### *System functionality*

. Given the significance of systems reliability-continuous availability and functionality, healthcare facilities are expected not only to put appropriate systems in place but also to ensure their undisrupted presence. Continuous updates therefore, are important in ensuring relevance, so that systems can always react to the current operational needs of the organization. In Fig. 1, the functionality of systems is presented as one of the key enablers (mediating factors) of system usage, without which users cannot effectively achieve their goals. Unfortunately, the findings reveal limitation in the functionality of existing HISs some sections/units of the hospital. For instance, *“...the radiology information system at radiology unit of the hospital had been non-functional for the past six months...”* (PRT6). Similarly, users in other units within the hospital complain of challenges with the systems such going off-line or having technical issues. An administrator admits that the systems *“...are very helpful, however there are many times when the systems go off-line and we have to wait for external people to come and fix the network... so we cannot do our jobs”* Functionality failures are serious with various implications to the work processes of the users within the activity system. These include *“long waiting periods for patients... sometime the patients have to referred to other hospitals or told to come back the next day, and the backlog of work”* (PRT7). What has emerged from these findings is that, in spite of these functionality limitations, the overall user-attitudes towards the system have not been significantly impacted. In fact, it emerged in the findings that users are very fond of the Delta9 and LHMIS systems. Opinions are that the issues with the systems, *“Delta9 is very helpful in terms of looking up patients’ information in a faster manner than the paper based system where you would be required to go into a store a manually go through stacks of paper work...”* (PRT3). Another respondent said that apart from the network slowness issues, Delta9 *“...makes my work very easy...”* (PRT4).

#### *Degree of Utilization (tools)*

. As discussed earlier, system functionalities, based on the analytical framework, can add full value to the medical personnel and other users’ work processes only if their potential is fully exploited. Having relevant reliable systems in place to support the daily operation of the users is paramount. To this, one participant mentions that *“...especially with the Delta9 system, there are some modules of the system that we are not using that would even make our job better...”* (PRT6). From the medical personnel point of a participant confirms that *“...although we can receive lab result on our mobile phone, some of us rarely utilise that functionality”* (PRT8). There is evidence in a correlation between functionality and usage limitations in the healthcare systems. Systems functionality failures have an inhibiting effect on the adequacy of health care delivery process in the public healthcare facilities. Apart from the system users that are affected by the system usage, other practitioners- because of the networking relationship in the working system, who depend on other system users for

relevant information. The head of ICT services at the hospital notes that “... we do get a lot of frustrated users who log in call for issues they are facing...” (Participant #7). Consultations with patients can be adversely affected.

In summary, ActAD framework suggests that, whilst usage of HIS to facilitate health-care service delivery is effected by enabling mediators, inadequate usage is an outcome of a negative interplay between the mediating factors, activities and actors. There are a number of constraints such as limited capacity of the network relative to the ever-increasing traffic and human errors as some of the reasons to the causes which lead to many of the systems functionality failures. There is still evidence of segmentation of infrastructure connectivity. Also, there seems to be a disconnection between e-health strategies/policies and the actual practice of the implementation and use of HISs in public healthcare facilities. With a focus on the context of a divergent national service delivery reality that impacts the right to healthcare service in under-served communities. This may suggest a need of a regulatory implementation framework guiding the implementation process of the HISs in public healthcare facilities within resource constrained environments.

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<sup>i</sup> PRT = Participant