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Model for context-fitting mobile services for monitoring delivery of public health services

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Abstract

Purpose: The study aimed at establishing the contextual factors affecting performance of mobile services for monitoring delivery of public health services in Uganda.

Methodology: The study used a qualitative research design in an interpretivist paradigm where the identified factors were subjected to analysis using documentary evidence and qualitative data from interviews. Using purposive sampling, six case studies among institutions responsible for monitoring health service delivery in Uganda were selected. Data was categorized through creating code families, grouping codes with similar attributes into broad categories and represent a higher order grouping of data from which the researcher began to build conceptual model and categories continued until saturation point.

Findings: It was established that lack of power for charging mobile devices, limited content and coverage of data captured by mobile technologies, limited man power, knowledge and skills of using mobile technologies and poor attitude of health workers, general nature of some mobile technologies, language barrier, poor connectivity and reliability of mobile and internet networks, insufficient supplies of health data collection and processing tools affect the performance of mobile services for monitoring delivery of public health services in Uganda.

Contribution to policy and practice: The study significantly contributes to a large body of knowledge in the adoption and use mobile technologies in monitoring delivery of public health services that has been less investigated in Uganda.

Keywords: *contextual factors; mobile technologies; public health service delivery; model for context-fitting mobile services*

1 Introduction

Public services are those services which are mainly, or completely, funded by taxation for a given government (Humphreys, 1998). Common public services include: health, education, security services, electricity and emergency services. The process through which these public services are brought to communities is known as the delivery of public services (Egberi & Madumelu, 2014). The delivery of public services is highly affected by corruption in form of high rates of staff absenteeism; leakages of public funds intended for schools, health facilities, or social assistance benefits; and shortages and stock-outs of pharmaceuticals and textbooks (Ringold, Holla, Koziol & Srinivasan, 2012).

Although corruption affects all public service sectors, the health sector appears to be particularly vulnerable due to uncertainty about the demand for services, the asymmetric information among the different actors, high degree of discretion given to providers in choosing services for patients, insulation from competition or external accountability and high decentralization of service provision (Vian & Nordberg, 2008). For example, of the estimated $7.5 trillion spent worldwide on providing health services each year, about 6% or $300 billion was lost to corruption and errors (Mackey & Cuomo, 2020). Thus, the public health service delivery was judged as a fitting case study of corruption in the delivery of public health services.

Many studies by different researchers and organizations have suggested that ICT more especially mobile technology has more potential to accelerate information dissemination, improve efficiency of public services and increase the transparency and accountability of government administration to reduce corruption, and facilitate citizen participation in monitoring delivery of public health services(Bhatnagar, 2014). As a way of harnessing this potential, a number of countries have embarked on anti-corruption initiatives using mobile technologies. Some of these initiatives include monitoring Tracking (mTrac)(Cummins & Huddleston, 2013), ChildCount+ (CC+) and Open Data Kit (ODK)(Holeman, Cookson, & Pagliari, 2016).

However, many such many such technologies have not performed well in practice. This is partly attributed to limited consideration of contextual issues affecting mobile technology performance when developing such technologies (Bruckner, 2019; Mohammed et al., 2016). Such contextual issues include user and task characteristics, technical, physical and social issues within a given environment and user motivation (Maguire, 2001).

This research paper addresses this gap, by proposing a model for context fitting mobile services for monitoring delivery of public health services that can guide development of context-fitting mobile services.

This study reviewed literature on existing information technology performance models and frameworks and components of context within the public health sector in Uganda.

The proposed model will provide system developers, policy makers, and adopters of technical solutions and managers of adopting organizations with information on how to improve monitoring delivery of public health services using mobile services.

2 Background

2.1. Context

According to Turel (2006), context can be understood in various ways and defined from a range of perspectives. From a psychological perspective, context is defined as a specific set of personal, physical and social characteristics of environments, behavior settings and/or situations selected for consideration by a researcher or designer, and the relation-ships between them (Clitheroe, Stokols & Zmuidzinas, 1998; Turel, 2006). These characteristics can be generally referred to as contextual factors and focal (or target) variables. From a computer science perspective, context is defined as information that characterizes the situation of an entity (Dey, 2001; Turel, 2006). A broader and more inclusive perspective argues that context is any personal and environmental information that may influence the person when using mobile services (Turel, 2006). For example, time can be an important personal contextual factor. Different times of the day can lead to different selections of mobile applications and to different patterns of use. Location is an example for an environmental contextual factor. Different locations can lead to different patterns of use (Turel, 2006). Turel also views context as the intersection of systems, stakeholders, users, tasks and environments (Turel, 2006). Similarly, Maguire defined context of use as an intersection of the users, tasks and equipment (hardware, software and materials), and the physical and social environments in which a system is used (Maguire, 2001). Abowd and Mynatt (2002) defined context of use in form of answers to the five 'W' questions: Who is using the system? What is the goal of using the system? Where is the system being used? When is it being used; and why is it being used? Accordingly, the description of each of these questions establishes a minimal set of necessary requirements for contextual fit of mobile services (Abowd & Mynatt, 2002). From these definitions and other literature reviews, a number of design strategies that characterize the development of context-fitting mobile services were identified. These design characteristics/attributes include; user characteristics (Maguire, 2001; Horner, Blitz & Ross 2014; Clitheroe, Stokols & Zmuidzinas, 1998; Turel, 2006), task characteristics (Maguire, 2001 ; Clitheroe, Stokols & Zmuidzinas, 1998; Turel, 2006), environment (Maguire, 2001; Clitheroe, Stokols & Zmuidzinas, 1998; Turel, 2006) and motivation (Turel, 2006). Based on the above definitions and other related literature, it can be observed that there are different factors that can influence the performance of mobile services across different contexts (O'Connor & O'Donoghue, 2015). However, some of these factors have not been considered when developing mobile services for monitoring delivery of public health services. This is partly explained by limited performance of these existing mobile services (Mohammed et al., 2016 & Bruckner, 2019). In response to the need for consideration of contextual factors in development of mobile services, the researchers proposed a model for context fitting mobile services for monitoring delivery of public health services. The model aligns the mobile services functionalities to contextual issues in the deployment environment.

Drawing on related studies, user characteristics (Maguire, 2001; Horner, Blitz and Ross 2014; Clitheroe, Stokols & Zmuidzinas, 1998; Turel, 2006), task characteristics (Maguire, 2001 ; Clitheroe, Stokols & Zmuidzinas, 1998; Turel, 2006), environment (Maguire, 2001; Clitheroe, Stokols & Zmuidzinas, 1998; Turel, 2006) and motivation (Turel, 2006) were identified as main context factors that influence performance of mobile technologies. Each of these factors is discussed below.

User characteristics: Many authors have highlighted the importance of user characteristics in developing IT systems. According to Li and Luximon (2018), these characteristics are necessary for learning new information and executing technology-based tasks. For instance, Maguire (2001) noted that the central part of the context when developing a system should focus upon the users of the product. Maguire suggested that a stakeholder analysis should be performed to identify all the different users of the system and their relevant characteristics. These characteristics may include knowledge, skill, experience, education, training, physical attributes and motor and sensory capabilities (Maguire, 2001). Relatedly, O'Connor and O'Donoghue (2015) also emphasized a need for consideration of cognitive factors - users' personal self-beliefs and ability, when developing mobile technology systems. Cognitive dimensions do play an integral role in the use of technologies in developing countries as it is reported that such regions face education limitations (computer illiteracy) and a lack of English language skills (O'Connor & O'Donoghue, 2015). Furthermore, Schmidt, Beigl and Gellersen (1999) identified user characteristics as one of the human factors related context that should be included in development of context-aware systems. They considered information on the user as knowledge of habits, emotional state, biophysiological conditions and others (Schmidt, Beigl and Gellersen, 1999). It is noted all these authors emphasize the importance user characteristics on technology performance.

Task characteristics: Another context factor identified in literature that influence performance of mobile services is task characteristics. Several researchers have also highlighted the fact that task characteristics have to be supported by characteristics of the computer system or product for it to achieve maximum performance. For example, Maguire (2001) noted that characteristics of tasks like frequency and duration of the task should be considered when designing a system. Descriptions of the activities and steps involved in performing the task should be related to the goals that are to be achieved. For the purpose of specifying user requirements, a key subset of contextual tasks should be selected to represent the significant aspects of the total set of tasks (Maguire, 2001.

Similarly, Schmidt, et al., (1999) also identified task characteristics (spontaneous activity, engaged tasks, and general goals) as one set of human factors related context that influence performance of an IT system or product. The two authors agree that task characteristics influence the performance of used technology; however, they differ on the specific task characteristics. Whereas Maguire (2001) emphasizes frequency and duration of the task, Schmidt, et al., (1999) highlight spontaneous task, engaged tasks and general goals. This implies that task characteristic that influence technology performance may differ depending on the kind of task and context.

Environment: Apart from user and task characteristics, environment is another contextual factor that influences the performance of technology. According to O'Connor and O'Donoghue (2015), contextual factors reflect external elements that comprise the environment or conditions for decision making tasks and as a result, such factors can vary across populations and industries. Cultural, economic, political and cognitive dimensions are important contextual factors because they influence how end users interact with mobile technology (O'Connor & O'Donoghue, 2015). Maguire (2001) also noted that when a product (or system) is developed, it will be used within a particular context. It will be used by a user population with certain characteristics. The user will have certain goals and wish to perform various tasks. The product will also be used within a

certain range of technical, physical and social or organizational environments that may affect its use (Maguire, 2001). In addition to Maguire's description of the organizational environment, Horner, *et al*., (2014) proposed administrative and organizational support as a necessary component of contextual fit. According to Horner and others, contextual fit includes the values and preferences of those making administrative decisions (Horner, *et al*., 2014). For example, support and monitoring by key leaders and a documented commitment to make the use of technology a standard operating procedure may be good indicators for administrative and organizational support. This confirms a need for consideration of environmental factors when developing context fitting mobile services.

Motivation: User motivation is another context factor that influences the performance of mobile services. Motivations are general characteristics that elicit, control, and sustain actions taken to fulfill a need or want (Salehan, Kim & Kim, 2017. Research on information and communication technologies has identified user motivation as an important factor for technology adopting and usage (Salehan et al., 2017)). Accordingly, users are goal oriented and select specific technology based on their needs (Salehan, Kim & Kim, 2017). The dimensions of user motivation may be characterized as content gratifications, process gratifications and social gratification (Salehan et al., 2017 and Kim, Kim & Kim, 2019). Motivation can also be based on a variety of factors like psychological and behavioral, economic and social aspects (Barabee & Depow, 2002 and Turel, 2006). Both researchers identified social benefits as a user motivation; however the other aspects differ for the different situations. Hence the need to identify user motivations in case of using mobile technology in monitoring delivery of public health services in Uganda.

2.2. Theoretical framework

A number of theoretical frameworks and models for evaluating information systems' performance have been developed, for example, (Aqil, Lippeveld, & Hozumi, 2009) developed the Performance of Routine Information System Management (PRISM) framework for evaluating performance of routine health information systems. Other theories include; End-User Computing Satisfaction (EUSC), Task Technology Fit (TTF), Technology to Performance Chain (TPC), Human-Organization-Technology (HOT) Fit Model, Technology Acceptance Model (TAM) (McGill & Klobas, 2009) and WHO Framework for categorization of digital health indicators(WHO, 2016). The TPC model among these theories is considered as one of the most relevant model for determining the performance impact of IS utilization by several IS researchers (Abdillah & Saepullah, 2018; Gebauer & Ginsburg, 2006; Gebauer, Shaw, & Gribbins, 2010a; Gebauer & Tang, 2008; Goodhue andThompson, 1995; Helbig, Gil-García, & Ferro, 2005; Junglas, Abraham, & Ives, 2009; McGill & Klobas, 2009; Osang, Abinwi, & Tsuma, 2015). However, Task Technology Fit is the pivotal construct of the technology-to-performance chain(D'Ambra, Wilson, & Akter, 2013) while WHO Framework focuses on digital technology performance in health service. Therefore, the three performance theories of TPC, TTF and WHO Framework were selected to guide the development of the proposed model.

2.2.1. Technology to Performance Chain

Goodhue and Thompson developed the TPC as a model to help users and organizations understand and make more effective use of Information Technology(Goodhue & Thompson, 1995). The TPC combines insights from research on user attitudes as predictors of use –

utilization in the TPC, with the notion of task–technology fit as a predictor of performance(Goodhue &Thompson, 1995; McGill & Klobas, 2009). TPC model proposes that task–technology fit is a function of task characteristics, technology characteristics, and individual characteristics. Task–technology fit in turn both directly influences performance, and indirectly influences utilization via precursors of utilization such as expected consequences of use, attitude towards use, social norms, habit and facilitating conditions. Utilization is also proposed to directly influence performance(Goodhue & Thompson, 1995). The basic argument is that for a technology to have a positive impact on individual performance, the technology must fit with the tasks it is supposed to support, and it has to be used (McGill & Klobas, 2009).

2.2.2. Technology Acceptance Model (TAM)

Technology Acceptance Model (TAM) was proposed by Fred Davis for his doctorate proposal as shown in 2.4 (Davis, 1989). As an adaptation of Theory of Reasonable Action, TAM is specifically tailored for modeling users' acceptance of information systems or technologies.

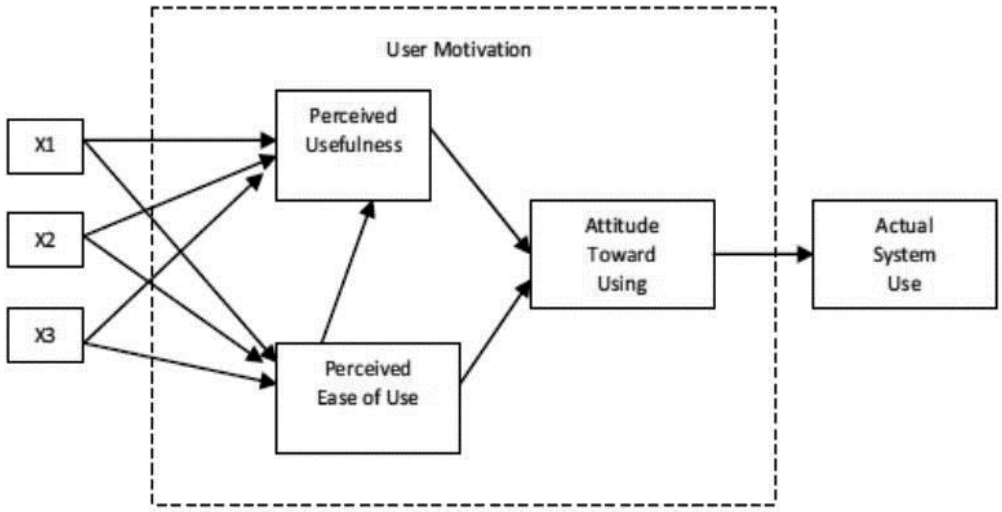

Figure 2.2.1: Original Technology Acceptance Model TAM Adapted From Davis (1989)

The basic TAM model has two specific beliefs: Perceived Usefulness (PU) and Perceived Ease of Use (PEU). Perceived Usefulness is defined as the potential user's subjective likelihood that the use of a certain system will improve his/her action and Perceived Ease of Use refers to the degree to which the potential user expects the target system to be effortless (Davis, 1989). The belief of the person towards a system may be influenced by other factors referred to as external variables in TAM.

2.2.3. Stimulus Theoretical Framework (STF)

Lai extended Technology Acceptance Model by including security and design factors to develop the Stimulus Theoretical Framework for the novelty technology of the single platform E-payment System (Lai, 2017). According to Lai (2016), the design and security are the stimulus that represents the system and features capabilities while, the perceived ease of use and

perceived usefulness are the organism that represents the motivation to use the system that leads to consumers' respond to use the system. Figure 2.5 shows the Stimulus Theoretical Framework by Lai.

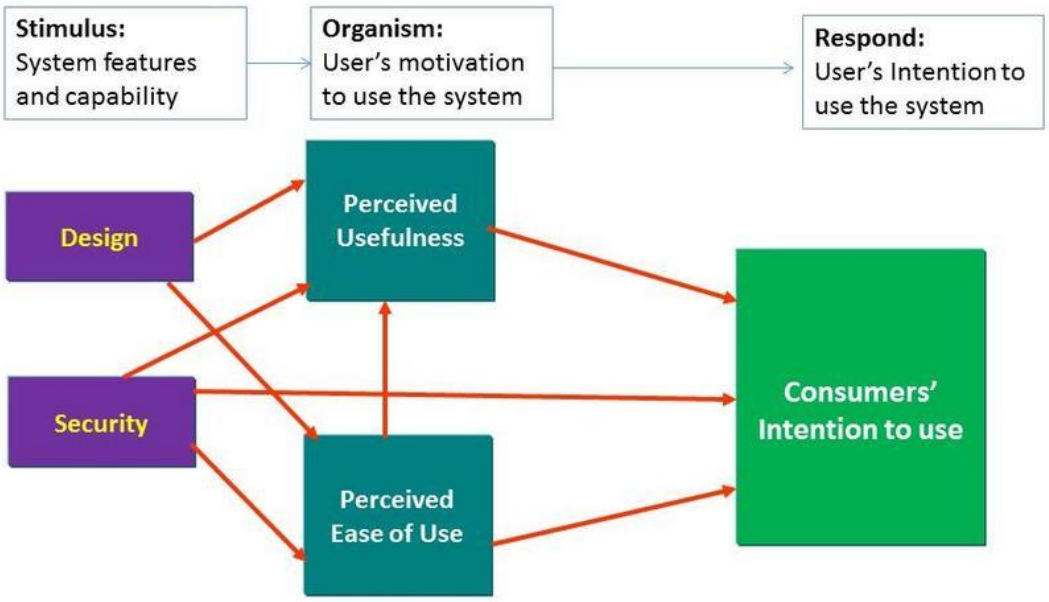

Figure 2.2.2: Stimulus Theoretical Framework adapted from Lai (2016)

2.2.4. Motivation-Participation-Performance Framework (MPPF)

Roberts, Hann, and Slaughter (2006) proposed a theoretical model (motivation-participation-performance framework) basing on Campbell and Pritchard's general social theory of motivation and performance. The model explains how different motivations of individual's behavior influences performance. According to this model, different people have different motivations, which, combined with their knowledge, skills, and abilities, produce task-related behaviors that lead to different levels of performance (Salehan et al., 2017). This framework is a general social psychology theory. However, similar to the case of Roberts et al.'s (2006) application of the theory to the open source software development context, it is useful to apply the framework to the specific domain of mobile services for monitoring delivery of public health services to explain individuals' context-specific motivation and performance.

2.2.5. WHO Framework for categorization of digital health indicators

WHO developed a framework for categorization of digital technology performance indicators for health (WHO, 2016) and classifies factors influencing digital health performance as technical and organization factors. Details are shown in the figure below.

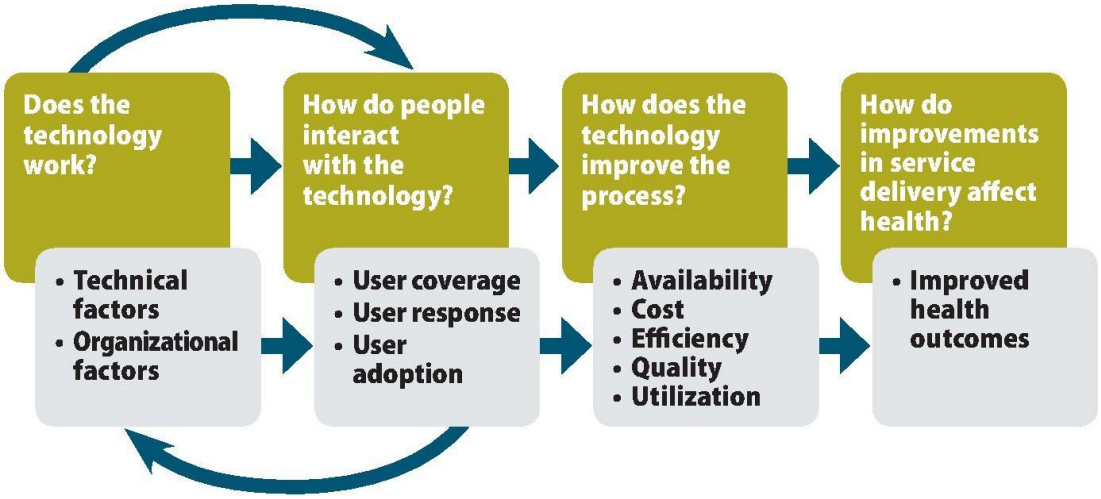

Figure 3: Framework for technology performance indicators by WHO (2016)

The framework provides a basis for assessing the performance of technology in a number of areas, like the technical and organizational aspects of the digitalized health system; the target audience's usage of and response to the technology; the technology's benefits to the process of health service delivery and its effect on improving outcomes (WHO, 2016).

According to the highlighted models, there are distinct factors that influence the performance impacts of technologies depending on the local context of any given country and sector. Therefore, there is need to design a tailor-made conceptual model specifically for digital anti-corruption for delivery of public health services in Uganda.

Table 1*:* A summary of context factors by existing models/frameworks

Contextual factors	**Models or Frameworks**					
	TPC	**WHO**	**TAM**	**STF**	**MPPF**	**PM**
User characteristics	Yes	Yes	No	No	No	Yes
Task characteristics	Yes	No	No	No	No	Yes
Technical environment	Yes	Yes	No	No	No	Yes
Physical environment	No	No	No	No	No	Yes
Organizational environment	Yes	Yes	Yes	Yes	No	Yes
Motivation	No	No	Yes	Yes	Yes	Yes

PM= Proposed Model

The summary presented in Table 1 that the technology to performance chain model by Goodhue and Thompson (1995) covers the highest number of contextual factors (4), followed by the World Health Organisation (2016) which cover 3 number of contextual factors and then Technology acceptance model and stimulus theoretical framework which cover 2 and motivation-participation-performance framework which covers one contextual factor.

2.3. Research model

Basing on reviewed literature, a range of potential factors were identified and adapted for inclusion in the proposed model (Table 1). First, several papers have identified design characteristics/attributes such as user characteristics (Maguire, 2001; Horner, Blitz & Ross 2014; Clitheroe, Stokols & Zmuidzinas, 1998; Turel, 2006), task and characteristics (Maguire, 2001 ; Clitheroe, Stokols & Zmuidzinas, 1998; Turel, 2006). Second, environment was also identified as important to influence performance of mobile services (Maguire, 2001; Clitheroe, Stokols & Zmuidzinas, 1998; Turel, 2006), and lastly motivation (Turel, 2006). Figure 2 shows the relationships among the identified contextual factors and performance of mobile services.

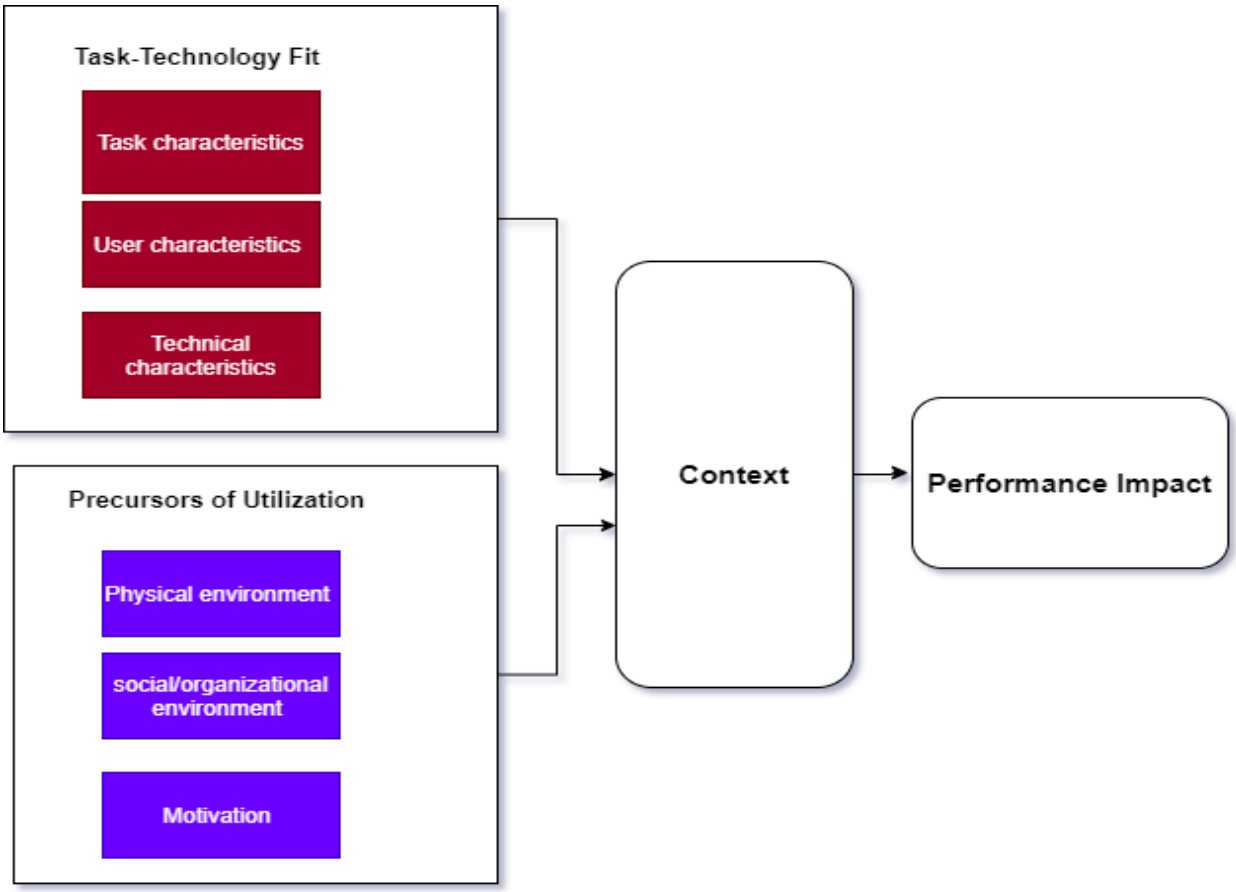

Figure 4: proposed conceptual model

The subsequent section discusses the depicted constructs.

Users: A user is a person who utilizes a service. When developing a system, it's important to describe relevant characteristics of potential users. These may include knowledge, skill, experience, education, training, physical attributes (like age, gender, physical capabilities, cognitive capabilities and limitations, attitude and motivation) and motor and sensory capabilities (Maguire, 2001).

Tasks: tasks are the activities undertaken to achieve a goal. Characteristics of tasks which may influence usability and performance of the system should be described, for example the frequency and duration of the task. Tasks should also be described in terms of the functions provided by a system, the activities and the required steps involved in performing the task to achieve stated goals (Maguire, 2001). Tasks and services are interrelated and cannot be separated (Turel, 2006). For example, the limited size of the screen and the inefficient input methods constrain the types of tasks that can be performed on mobile devices (Turel, 2006).

Technical environment: the technical environment is the software, hardware, network and other equipment which is used in conjunction with the system. The characteristics of the technical environment (such as the speed of the processor or the layout of keys on the keyboard), may have an effect on the system usability and performance (Maguire, 2001).

Physical environment: the physical environment can have a profound effect on the usability of a system. The physical environment is structured into three categories: location, infrastructure (like surrounding resources for computation, communication, task performance), and physical conditions (like noise, light, pressure) (Schmidt, Beigl & Gellersen, 1999; Maguire, 2001 & Horner, et al., (2014)).

Social or organizational environment: the attitudes of the organization and its employees towards the introduction of system, work monitoring system, the way people work (individually and in groups), the availability of assistance and the frequency of interruptions, affect the usability and performance of a system (Maguire, 2001). Horner and others also noted that mobile services should match the values and preferences of those who will (a) implement, (b) benefit from, and (c) manage and support services. Personal, societal, cultural, and professional values matter. The type of service, how it is implemented, and the intended outcomes should be acceptable to those in the local setting (Horner, et al., 2014).

Motivation: this dimension of context defines the motivation of the users to utilize mobile services. User motivation can be based on a variety of factors: psychological and behavioral, economic and social aspects (Turel, 2006). The broad range of mobile services generates a numerous number of motivations ranging from social drivers like peer pressure and group norms to specific individual risk aversion and cost-benefit analysis. For instance, among the motivations to use wireless games one can include the entertainment value and group norms among teenagers. In line with that, researchers suggest that SMS prevailed in some markets due to the 'entrainment' value it provides and its low cost which result in a strong value proposition (Barabee & Depow, 2002).

Table 2: Summary of derived framework constructs and variables

Component	Component characteristics/features
Task	• Task complexity • Task time criticality • Task complexity • Task frequency
User characteristics	• Training • Computer experience • Motivation.
Technical environment	• Platform (Weight, size and screen size) • Technology functionality • Technology adaptation to the local context.
Physical environment	• location, • infrastructure (like surrounding resources for computation, communication, task performance), • physical conditions (like noise, light, pressure)
Social/organizational environment	• Structure: group working, work practices, assistance, interruptions, management structure, communications structure, salary • Attitudes and culture: policy on computer use, organizational aims and industrial relations • Job design: job functions, hours of work, job flexibility, performance monitoring, performance feedback, pacing, autonomy, discretion
Motivation	Motivational value like entertainment, low cost

3 Research Methodology

Using recursive research process of Gorman, Clayton, Shep, and Clayton (2005), the study was implemented in three stages:

(1) developing an initial conceptual model;

(2) testing the model with qualitative data; and

(3) revising the conceptual model.

Based upon the literature, an initial model was created with several contributing factors that might influence the performance of mobile services for monitoring delivery of public health services in Uganda. The study used a qualitative research design in an interpretivist paradigm where the identified factors were subjected to analysis using documentary evidence and qualitative data from interviews.

Using purposive sampling, six case studies among institutions responsible for monitoring health service delivery in Uganda were selected. The selection was based on the Ministry of Health's

Management structure, location and accessibility. The location of selected institutions was distributed in urban, peri-urban and rural areas of four districts in Uganda, namely Tororo in the Eastern region, Mitooma in western Uganda, and Wakiso and Kampala in central region. In addition, the selected institutions covered central government agencies, local government agencies and one NGO. The six institutions are: Ministry of Health (MoH), Uganda National Health Consumers Organization (UNHCO), Office of the Prime Minister-Delivery Unit (OPMDU), Tororo District Local Government, Mitooma District Local Government, and Wakiso District Local Government.

Seventeen participants were purposively selected from the six institutions to participate in interviews. The basis for the selection was involvement in monitoring health service delivery. An unstructured interview guide was used to collect information from the chosen respondents about monitoring tasks and their requirements, mobile technologies used their functionalities and factors influencing their utilization. Other information of interest includes; stakeholders involved and their characteristics, as well as recommendations for improvement.

Preparation and analysis of excerpt from the transcript involved interpreting the interaction between the interviewer and participant. Each transcript was anonymized to ensure confidentiality. Later codes were developed through gathering of the ideas, opinion, views and topics discussed by the participant. The purpose of identifying codes was to identify the range of issues raised in the data, and understand the meanings attached to these issues by participants. Therefore, codes were used as topical markers to index the entire data set so that one can easily locate every place in the data where a specific issue was discussed. Software Nvivo 12 was used to facilitate the process of coding. Data was categorized through creating code families**,** grouping codes with similar attributes into broad categories and represent a higher order grouping of data from which the researcher began to build conceptual model and categories continued until saturation, when the researcher could not identify further categories in the data.

4 Contextual factors affecting performance of existing mobile technologies

This study was intended to establish contextual factors that affect the performance of mobile services for monitoring the delivery of public health services in Uganda. The reviewed literature identified user characteristics, task characteristics, and motivation, technical, physical and organizational environment as the main categories of contextual factors that influence performance of information systems. In addition to these factors, government policy and accessibility emerged from the interview data. Within each category, relevant features were identified, from interview data, whose values determined context in monitoring delivery of public health services in Uganda. The findings are presented below.

4.1. User characteristics

Data from the interviews and the documentary evidence pointed user characteristics as one of the most influential factor affecting performance of mobile services for monitoring delivery of public health services in Uganda. The most highlighted characteristics are user knowledge, skills, attitude, phobia of technology and English literacy levels. For example, most of the participants interviewed identified limited knowledge and skills as a major challenge of using mobile

technologies. This problem was confirmed by the senior clinical officer from Mitooma district local government as follows

"*Most workers here are not willing to assist in compilation of reports because it requires commitment, knowledge and skills which they do not have*".

Similarly, another participant responded:

"*Some staff do not have the necessary skills and expertise to collect and send data using mobile phones. Therefore, when you are absent no one is able to stand in for you".*

Another participant also noted that:

"The tool we use for data collection requires specific knowledge and skills which the public does not have. We take time to train our staff on how to use these tools and we cannot train the general public".

The skill and knowledge requirements also extend to maintenance and repair of mobile devices. For example, according to the Programme Officer with Uganda National Health Consumers Organisation, while using ODK, only project engineers could repair and maintain the used mobile phones and when project ended there was no one to take on the role of these engineers.

Interview results also indicate that some health workers have negative attitude about data collection, poor information use culture, and commitment, all of which affect the use of mobile technologies for in data collection, analysis and reporting about health service delivery.

It was also noted that language barrier also affects the use of mobile technologies in monitoring delivery of public health services. All identified mobile technologies are programmed in English and yet not all potential users such as VHTs and general members of the public know English. A senior Pharmacist from ministry of health in charge of monitoring medicine and other health supplies countrywide noted that:

"…..*the biggest challenge now is that our country Uganda does not have a common language like other East African countries where Kiswahili is used by all categories of people. Therefore, a good tool should take care of the different local languages in the country side*". This is an indication that there are no mobile services which are operational in the language of the users.

4.2. Task characteristics

Another important factor that influences performance of mobile services is task characteristics.

The identified task characteristics are task complexity, task-time criticality, task frequency, task–cost and task security.

Task complexity: some monitoring tasks are considered complex and others simple. For example, interviewed users considered data analysis more complex than data collection and analysis. It was also noted that users are enthusiastic to use a technology with potential to reduce task complexity.

Task-time criticality: timely access to information was identified as one of the main benefits of using mobile technologies. For example, a commissioner in the MoH said:

"I can tell you now when the minister asks for information, the people from the resource center just say give me 2 minutes, and they give you live information".

Also, an officer in charge of Kashenshero health III noted that:

"……using mTrac is less tedious and handy because we send coded data and therefore one can sent a lot of data in near real-time for immediate monitoring…"

Mobile service users are motivated to use the service when it assures them timely access to information.

Task–frequency: findings on monitoring tasks suggested that some tasks are performed more often. For example, reporting of data on health service delivery tasks is done on monthly basis and others, weekly and quarterly or daily basis. Mobile service users prefer to use mobile services on more frequent tasks.

Task–cost: interview findings suggest that users attach a lot of importance on cost for performing a task. Users are more motivated to use mobile services when the service is perceived to reduce the cost of performing a particular task. Most participants confirmed using mobile technology tools to collect and disseminate information because it has made the process much cheaper than before. For example, it was noted that use of mTrac has reduced costs for papers and transport.

Task–security: the reporting of data on corrupt behaviors through mobile technology is a primary concern for whistle blowers in public service delivery. Participants noted that the mobile services should have strong controls at administration level to ensure user confidentiality. Interview participants emphasized that mobile services users are willing to volunteer information if they are assured of confidentiality and security.

4.3. Technical environment

Study participants also identified limited content and coverage of data captured by mobile technologies as a big challenge. The used mobile technologies are mostly SMS based and SMS has limitations on data capturing capabilities. This limitation affects the quality of data submitted such as level of completeness which in turn reduces the value of such data for effective monitoring of public health service delivery. For example, mTrac- main tool used by Ministry Health does not capture some variables of interest such as staff attendance records. Also, like other SMS based mobile applications, mTrac has limited flexibility of its user interface and is only practical with simple text information and short forms. Data that requires large forms and a variety of data types like GPS and photos cannot be easily handled by mTrac.

Furthermore, some mobile technologies are not selective in data capture and also require sending information on all items including those for services which are not offered at the health facility which wastes a lot of time. A case in point is mTrac which takes in anything that is typed and also requires you to fill for services not at your centre. Mobile service users also indicated the need for the service to meet the needs of different groups of people and to carry relevant information.

4.4. Physical environment

Most study participants identified lack of power for charging mobile devices as a major challenge to the effective use of mobile technologies in monitoring delivery of public health services especially in rural areas. One participant from a district said the following in response to this question:

"Power for charging mobile phones is a big challenge as most rural areas like ours are often not connected to the main power grid".

This is a big problem given that majority of the health facilities in Uganda are located in rural areas where there is limited and unreliable power supply. Thus, charging mobile devices raises maintenance costs as it involves sending them to nearby trading centers for charging which attracts both transport and charging costs.

The poor connectivity and reliability of mobile phone and internet networks is also another challenge for many mobile technology users. For example, SMS messages in Uganda that run through third party aggregators generally get reprioritized against person-to-person messages and advertisements run by the telecoms themselves. This leads to long message queues and delays of up to a day. This was reported a major issue with mTrac as it scales nationally.

4.5. Social or organizational environment

Another major challenge affecting use of mobile technologies in health facilities and monitoring delivery of public health services is limited man power. Most of health facilities do not have designated staff for managing data collection, analysis and dissemination. The understaffed health workers who provide health care services are also supposed to handle data which they sometimes do not prioritise because of a lot of workload.

For example, a participant commented:

"*The process is hectic, without a records assistant, health workers are the ones responsible for compiling data. The health workers already have a heavy load attending to patients, at times they have activities outside the health facility, attending meetings and workshops, and time becomes really limited. Therefore, there is little time for them to capture all the data and then compile reports for sending using mobile phones. You have to work during the night to compile such reports".*

The mode of project implementation under which some mobile technologies in health care service delivery is implemented are sometimes unsustainable. Most use of mobile technologies in health care service delivery is mainly donor funded. Mobile technologies used are normally abandoned at the end of the project due to lack of funding and institutional support. According to the Programme Officer with UNHCO:

"ODK and Text to Change were being implemented under a project mode and projects have a life span, so the life span for those projects expired". "The project under which we were using smartphones with supervisor (apd) ended and the application was proprietary and therefore we no longer access it".

Insufficient supplies of health data collection and processing tools in health facilities also limit the use of mobile technologies. Mobile technologies are mainly used to transmit health data from communities and lower level health facilities to higher levels. However, the primary data capture is majorly done with hard paper forms which are supplied by Ministry of Health and other implementing partners. Failure to capture this data means, there will not be any data to use with the mobile technologies.

4.6. Motivation

Most of the interviewees believed that some mobile service users especially the citizens who are supposed to report corrupt behaviors lack the motivation to do so. This was explained by some users demanding for payment whenever asked to report suspected corruption cases. Also other potential users showed general lack of interest and ignorance about giving feedback on public health service delivery.

4.7 Government Support

Government is responsible making policies and laws, securing funds and management of public resources all of which are necessary for IT infrastructure development. Thus, Government was highly acknowledged as an influential factor affecting the performance of mobile services in Uganda. For example in Uganda, mTrac is a Ministry's led service innovation**,** approved by ministry. Also study participants noted that sometimes the public is not involved in data collection, analysis and dissemination because the activities are restricted by existing government structure where the work is only restricted to districts health department teams. A participant noted:

"It is government policy to use Mtrac in data management and that is why are still using it. When they bring a better technology, we will go with that".

4.8 Revised Model of contextual factors

Based on data analysis results, the proposed conceptual model was revised accordingly. There are few changes between the proposed conceptual model and the final model. First, among the user characteristics of knowledge, skills, attitude, phobia of technology and English literacy levels were found relevant for this study. Second, cost and security characteristics were added to the initial task characteristics identified in literature since they were emphasized to influence mobile service usage.

The task characteristics were extended to include the cost and safety of performing a particular task since they were emphasized as some of factors that influence usage of mobile services for monitoring delivery of public health services.

Government policy was separated from social or organizational environment because interview data indicate that the government has a big influence on adoption and usage of mobile services for monitoring delivery of public health services than making policy. Thus, factor- government was created that is much broader.

Limited accessibility was added as a new contextual factor that affects the performance of mobile services. Interview data shows that mobile device users face accessibility barriers like

slow Internet connections if they are located in a rural area or lack the financial resources to buy mobile devices, data for internet connections and mobile applications.

The revised model

The eight major contextual factors affecting the performance of mobile services for monitoring delivery public health services are grouped into two categories:

1) Internal factors which include user characteristics, task characteristics, technical environment, social or organizational environment, motivation and accessibility;
2) External factors, which include government and physical environment.

These factors have different levels of influence on performance of mobile services and are inter-related. The factors are presented in Figure 3 below.

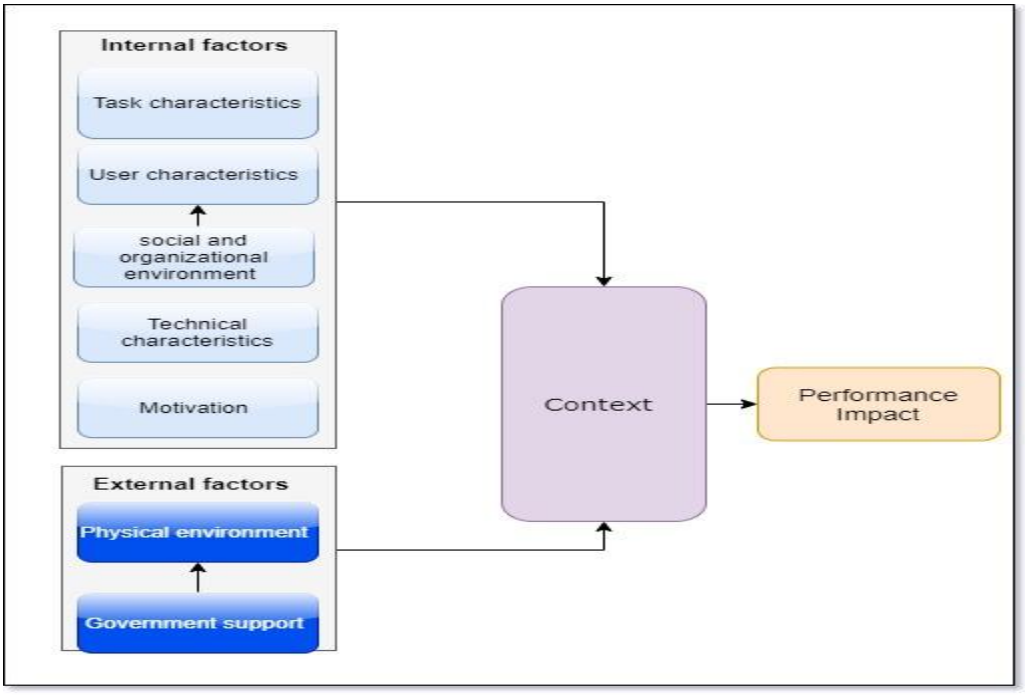

Figure 5: Revised Model

In figure 3, the "relationships" arrows present the relationships between factors. For example, the Government factor influences the physical environment.

Government: government directly affects the development of the IT infrastructure through policies that prioritise investment in IT and creates essential IT infrastructure for health and other sectors. This creates the environment required for the development and use of mobile services.

User characteristics: user characteristics such as attitudes are one of the most important factors that affect the performance of mobile services in Uganda. In its relationships with other factors, the user characteristics factor is influenced by social or organisational environment.

Social or organisational environment: The aspects of this factor such as group working, work practices, assistance, interruptions, management structure, communications structure, salary, culture and lack of cooperation among organisations staff influence the performance of mobile services. In its relationship with other factors, it affects user attitude. There was no clear relationship among the remaining factors of task characteristics, technical environment, physical environment, motivation and accessibility.

5 Discussion, Conclusion and Recommendations

The main aim of this study was to find out contextual factors affecting performance of mobile services for monitoring delivery of public health services in Uganda. This was achieved through establishing what mobile technologies are being utilised to monitor delivery of public health services and context factors limiting/facilitating their performance.

The study findings indicate that a number of mobile technologies are being used to monitor delivery of public health services; some of these technologies have registered considerable successes but successful implementation of others has been faced with considerable challenges.

Results from the study indicate mobile Tracking, AKVO flow, Bespoke and Open Data Kit as the commonly used mobile technologies/tools/systems in fight against corruption public health services. Among these mTrac is the most commonly used tool because it is government policy for public health facilities to use it. This is in agreement with WHO report which indicated that in Uganda, mTrac is a Ministry of Health led service innovation for monitoring delivery of public health services(World Health Organization, 2014).

Furthermore, results indicate that all these identified mobile technologies are mainly used for data/information collection, processing and dissemination. Hence these technologies have enabled easy reporting of corruption incidents in delivery of public health services. The findings concur with the findings of (Bhatnagar, 2014), who also found out that ICT can be used to accelerate information dissemination, improve efficiency of public services and increase the transparency and accountability of government administration to reduce corruption. However, it should also be noted that ICT can support anti-corruption measures in many different ways like service automation to replace discretionary making and automated audits all of which are not catered for by the existing mobile technologies (Holeman et al., 2016).

The study findings also established number factors that affect the performance of mobile services in monitoring delivery public health services. Most study participants identified lack of power for charging mobile devices, limited content and coverage of data captured by mobile technologies, limited man power, knowledge and skills of using mobile technologies and poor attitude of health workers. Other challenges included general nature of some mobile technologies, language barrier, poor connectivity and reliability of mobile and internet networks, lack of sustainability, insufficient supplies of health data collection and processing tools in health facilities which are source data for these technologies. The findings corroborate that of(Hellström, 2010) who noted that ICT capacity in East Africa is low and there is a lack of training and skills development.

Also, the findings concur with Ebo, Amosa and Adenusi (2012) who found out that majority of health facilities in developing countries are located in rural areas. The rural areas are usually not

connected to the power grid and when connected, such power is usually extremely unreliable that recharging the mobile devices becomes a serious challenge as it raises maintenance costs.

These challenges need to be addressed in order for current and future mobile technologies to be more beneficial in the fight against graft in the health sector especially in developing countries. In order to address these identified challenges for improved performance of mobile services in monitoring delivery of public health services, a context- fitting model was proposed. The model includes both external and internal contextual factors that influence performance of mobile services.

In conclusion, the study revealed that many mobile services are being used in monitoring delivery of public health services. However, much as there some benefits gained in using these technologies, there are still many challenges encountered. These challenges affect performance of mobile technologies for monitoring delivery of public health services. It is anticipated that adoption and use of the proposed model can greatly improve the performance of these technologies.

The proposed model with its seven most important factors illustrates the context in which mobile services for monitoring delivery of public health services in Uganda can be designed. Those who are involved with development of mobile services for monitoring delivery of public health services can use the model to appreciate opportunities and challenges they will face when using mobile services. The model also shows relationships between factors, for example, how government influences the physical environment. If government can be supportive, it can improve the IT infrastructure that will facilitate performance of mobile services.

The main limitation of this work is lack of validation of the proposed model through in-depth case studies with domain experts. This limitation creates a basis for our future work.

Recommendations

The study suggests that government should:

Adapt them to Local languages: Cater for local languages as some potential users do not know English.

Provide support services to end users: Initiatives that provide mobile devices to end users should provide additional training support, repair and maintenance of devices and availability of power for charging them.

Develop/acquire custom tailored mobile technologies for monitoring delivery of public health services or specifically aligned to specific forms of corruption to improve their performance.

Provide computers and power back-ups and internet to health facilities, deploy IT support staff and M&E professionals to all health facilities, and create awareness on the importance of data / information collection among health workers and on job training of health workers in computer literacy.

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