Leveraging on Cloud Technology for Reporting Maternal and Child Health Services at the Community Level in Ghana.

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Background and Purpose: The Millennium Development Goals (MDG) has served as a catalyst in galvanizing governments and ministries to refocus their development agenda to meet set MDG targets. Similarly the Ghana Health Service (GHS) recognizes the importance of an efficient health information system (HIS) for generating quality data for monitoring progress towards achieving set targets of the health related MDGs 4, 5 and 6. This paper is therefore to describe the GHS effort in using electronic health record system called the e-Tracker to support the provision and reporting of primary healthcare in the area of maternal and child health services at the community level.by leveraging on contemporary cloud computing technologies.

Methods: The research approach was case study of selected facilities in one pilot district. Empirical data was collected using qualitative methods such as participant observations, interviews and supplemented by secondary data sources such as training manuals and other official documents. Philosophically the research was informed by interpretive paradigm through subjective meaning for understanding the sociotechnical complexities of implementing the e-Tracker in the health domain. Actor-Network Theory (ANT) was considered as an appropriate theoretical lens to conceptualize and investigate the dynamics of introducing a technological artefact into a social system such as the health domain.

Results: Findings were that there was realignment of work practices with resultant reflexive effects (positive and negative) on the working environment as a result of introducing information technology artefact into the health domain. And that the sociotechnical effects are emergent and cannot be determined a priori because of the multiplicities in complexity when the social reacts with the technical.

Conclusions: These findings corroborate findings in similar studies in the IS literature in that effects of technological artefacts in complex social-technical system are emergent and cannot be predetermined due to their unpredictability. Furthermore, in sociotechnical systems such as the health domain best practice is for the coexistence of electronic and paper systems. Therefore, an attempt to completely replace the paper system with the electronic system may result in system challenges.

Keywords: e-Tracker, Electronic Health Record, Maternal and Child Health

1   Introduction

The year 2000 was the birth of the eight Millennium Development Goals (MDG) when 189 countries declared at the millennium summit of the United Nations to achieve set targets by the year 2015 [47]. In the health domain this declaration served as a catalyst to galvanize governments and health ministries in developing countries to revamp their health systems to meet set targets for the health related MDGs 4, 5 and 6, that is, Reduction in Child Mortality (MDG4), Improving Maternal Health (MDG5) and Combating HIV/AIDS, TB, Malaria and other Diseases (MDG6) [16][49][55].

Maternal and Child Health (MCH) services form part of the universal health coverage package for the under privileged and this is very significant in developing countries where majority of the population live in the rural areas where healthcare infrastructures are in very deplorable state or non-existent [56]. The safe motherhood and child welfare services include Antenatal Care (ANC), supervised Deliveries, Postnatal Care

and Family Planning (FP) services respectively. Under these programmes it is assumed a pregnant woman will receive the necessary quality healthcare through pregnancy, delivery and after delivery. And the child similarly, going through all the child welfare programmes from infancy to about five years when it will be out of danger zone for possible childhood diseases [57]. Because of the poor state of the health infrastructure in developing countries health ministries are finding it difficult to provide these range of MCH services and in cases where they are provided, the quality is found wanting. Studies have therefore shown that many pregnant women and children do not receive the full range of the MCH services especially in rural settings. In addition, these studies have also shown the existence of gaps in terms of service provision and reported data for monitoring and evaluation of such services [11][17][29][56].

In the contemporary health domains records of health service provision and the corresponding data generated are managed by a combination of paper and electronic systems. In many countries today Electronic Health Record (EHR) systems are seen and being implemented as a way of bridging the quality gap in providing healthcare and reported health data [26]. With respect to developing countries the literature talks about studies on implementation of EHRs to support healthcare. However, the common characteristics of these EHRs implementations are that they mostly are on pilot basis and target specific health service area or programmes (diseases, logistics, some family health services such as ANC, FP, etc.). These projects normally fail to scale after project expiration because of lack of funds for sustenance [9][18][31][36][41][42]. Furthermore the evaluation of such EHR projects in developing countries are said to focus on rational quantitative outcomes which often lack scientific rigour and also downplay the social dimensions of human-technology interplay.

The GHS is implementing an Electronic Health Records (HER) system called the e-Tracker at the Community-based Health Planning and Services (CHPS) compounds and zones to support MCH services and data reporting which hitherto has been facing a number of challenges. The e-Tracker is an individual client-based module in the DHIS2 which is being implemented in public health facilities in Ghana. The GHS' experience in EHR implementation in its facilities has been just up to the district level and it is now in the process of scaling to the community level. This paper is therefore on the experiences in piloting the e-Tracker in selected districts prior to national rollout. The practice of scaling or decentralizing a national HIS to the community level in developing countries may not be possible due to peculiar problems such as the availability of appropriate infrastructures and personnel. And it may be of interest to study Ghana's effort in relation to the effects of technology on work practices, the health domain and health personnel using the system.

The objective of this study therefore is to use qualitative techniques to understand the dynamics of the emergent effects of using the e-Tracker in providing MCH services at the community level in Ghana. In doing so the research will try to answer the following question: *How will the implementation of Electronic Health Record system impact on the provision of Maternal and Child Health service at the community level in Ghana?* Here community level refers to rural settings in Ghana. Answers to the research question could give insights into providing and improving the quality of MCH services and reporting in similar settings.

The rest of the paper is organized into the following sections. The next section presents the materials from relevant literature and theoretical concepts. Section three presents the research context followed by research method in section four. Case description, findings and discussions, and concluding remarks are presented in sections five, six and seven respectively.

2   Materials from Related Literature Review

The past three decades have seen many advances in Information, Communication and Technology (ICT) and their use in many spheres of human endeavours. In developing countries ICT is being used in commerce, banking, health, oil exploration, to mention a few [3][19][33][43]. The IS literature reports of variants of EHR systems implementations in the health sector to support and enhance different health services and programmes. For example, there have been reports on implementation of EHR projects to support MDG6 (combating HIV/AIDS, TB, malaria and other diseases), primary healthcare programmes such as safe motherhood and child welfare, human resource and clinical care [16] [27][28][44][53][57]. In executing such EHR projects and depending on the context, one could see the use of combination of ICT artefacts such as mobile phones, tablet computers, laptops, desk top computers, internet, cloud technology, different software, etc. These assorted technological artefacts have a range of functionalities that comes to bear on EHR implementation in developing countries. And these can be seen in clinical care, data processing, logistics management, continue of care, health statistics generation and reporting, and so on [1][4][10][54].

Implementation of EHR systems in developing countries has been associated with a number of challenges. Some of the challenges that have been identified are lack of basic infrastructure such as supply of regular electricity, poor internet connection, technical support in case of equipment failure, high staff turnover and lack of skilled manpower e.g. computer literacy, in that most often end-users have to be trained in basic computer skills prior to EHR deployment. The implication of these challenges is increased workload on the few available staff [3][11][12]. Characteristically most of these EHR projects are donor initiatives which are executed on pilot basis for quick results with little or no local government's influence. And very often when the project period expires the local government is unable to find the necessary funds to continue from where the donors left off. The implication of these scenarios is pilot projects dotting EHR landscape and unable to scale to become sustainable [2][25].

Despite these challenges there have been some success stories in EHR implementations. The literature reports evaluation studies where EHR systems have been used for continue of care of clients' enrolled in MCH services, TB and HIV/AIDS programmes where clients are followed up on medication and for defaulting on treatment [24][48][49]. Other studies have also reported efficiency in the provision of healthcare by reduction in waiting time at health facilities, electronic transmission of laboratory reports on radiology between different facilities located at different places in a country, patient notification on treatment regimens, etc. [44][45]. One other area where studies have shown positive benefits in EHR implementation is in improving the quality of health data. Inscriptions of validation rules during the design of EHRs had resulted in reduction in data entry errors during implementation. The implication of this is to make end-users aware of the essence of inputting the correct data in order to improve data quality [11][13].

However, in many of these EHR studies the tendency has been to focus on predefined and rational effects to the neglect of emergent sociotechnical effects emanating from interaction between technical artefact and the social context [50, 6]. Researches in the IS domain underscore that such effects are best understood by adopting sociotechnical perspective using qualitative techniques. It is argued that using qualitative techniques permit an in-depth and thorough investigation of planned and emergent effects [6, 5, 50]. EHR implementation in the health domain results in technical artefacts interacting with the social and affect work practices, the health domain and introduces other side effects. This study will therefore try to evaluate these sociotechnical effects in the evolution of the e-Tracker in Ghana [6][22][50].

2.1   Theoretical Concepts

This study draws on network concept in Actor Network Theory (ANT) and how actors in the network align themselves at different phases of the network formation [39][40]. The central idea of ANT is to investigate and theorise on formation of networks, to follow what associations exist, their trajectory, enrolment of actors into a network, and how networks achieve temporary stability or otherwise. The purpose is to gain detailed insights into the manifestation of sociotechnical effects. This conceptualisation provides an analytical tool for investigating complex interaction between human actors and non-human actants in a social system where actors are considered equals.

The introduction of a new EHR system such as the e-Tracker in the health domain requires the formation of new connections with existing network components to re-organise around this new actor. And ANT can help to gain a deeper insight into the processes involved in the network formation. This can then result in recommendations of how to make the new network - i.e. one now including both humans and technology - more stable and in so doing facilitate the effective integration of the technology into the healthcare environment. Despite ANT's practical applicability it has been criticised as being too descriptive, failing to offer suggestions of how actors should be seen, and how their actions should be analysed and interpreted [37].

3   Context of Ghana

This study was conducted in one of the coastal districts of Ghana where majority of the population are subsistence farmers, fishermen and petty traders living in villages and small towns. In Ghana the MOH is the largest stakeholder in the provision of formal healthcare. Their effort is complemented by private, faith-based and quasi-government health facilities. Informally healthcare is also provided by divine healers in prayer camps, shrines of traditional healers, herbalists and Traditional Birth Attendants (TBA).

The MOH provides health services at three levels namely the primary, secondary and tertiary respectively. Health facilities at the primary level consist of the health centre (HC), clinics and CHPS compounds/zones,

with the CHPS compounds and zones being the lowest health facility at the community level [27]. The difference between a CHPS compound and a CHPS zone is the former has a fixed structure within the catchment area comprising of a clinic and living quarters for the health staff. Whist for the latter the health staffs live outside their catchment area and visit the communities for outreach services. The secondary level of healthcare comprise of the district and regional hospitals, and the tertiary level is made of specialist health facilities such as leprosaria, teaching and psychiatric hospitals, cancer and cardio centres respectively.

At the primary level the CHPS compound is the most easily accessible health facility with catchment population of between three to five thousand people. The CHPS compounds are managed by two to five Community Health Nurses (CHN) who are MOH/GHS staff. They are supported by Community Health Volunteers (CHV) who together are expected to provide among others MCH services such as ANC, Deliveries (where there is a midwife), PNC and FP services. The health staffs at the CHPS also provide outreach services to all households in the catchment area with the intention of bringing healthcare to the people wherever they are domiciled. The CHPS concept in Ghana is a novel model that strives to bring healthcare to the door steps of the people in their various communities [20][21]. Any health complications observed at the CHPS level are referred to the HCs and the HCs likewise refer any health complications that could not be handled at their level to the hospitals which provide a range of health services capable of handling most complications.

According to the 2010 Population and Housing Census (PHC) report the Ghanaian population is slightly urban with 50.9% living in towns and cities with the remainder living in the rural areas. The country is divided into 10 regions and apart from Greater Accra (90.5%) and Ashanti Regions (60.6%) which are urbanized; the remaining eight regions have their populations concentrated in the rural areas. That is Volta (66.3%), Northern (69.7%), Upper East (79.0%) and Upper West (83.7%) regions have most of their populations in the villages.

This study evaluated the implementation of the e-Tracker in two Health Centres (HC) and two CHPS compounds in the selected district. This is for the purpose of having an overview of the full range of services provided under the MCH programme. The reason is that almost all the CHPS compounds do not have midwives and so do not conduct deliveries unless in emergency cases. The study will also look at the sociotechnical factors impacting on the implementation of the e-Tracker in the district. Lessons learnt may therefore inform improvement in the artefact design and scaling-up to the rest of the country.

4   Research Method

This is a case study of the e-Tracker pilot in some selected facilities at a district in Ghana. Case study was used because it enables an in-depth understanding and analysis of contemporary contextual issues and their relationships [40]. The epistemological lens is qualitative and interpretive where environmental actors' subjective meanings are studied and analysed [32][34]. I also participated in the implementation process with respect to system development, training and deployment. Such close involvement in this project has given me the opportunity to observe system activities, access documents, discuss and interview many stakeholders at different levels over time and space.

4.1   Data Collection

Data collection was through participation in software customization processes, training of end-users and software implementation at pilot sites. Other qualitative data collection methods used were observation of work processes and practices at health facilities with focus on health service delivery and data reporting, discussions with health staff at the facilities, 12 interviews with different heads of departments (ANC, Delivery, PNC and Family Planning) and analysis of different documents such as ANC registers, Child Health Records, Maternal Health Records, etc. and training manuals. At the facilities visited care-givers as well as pregnant women and mothers attending PNC and Child Welfare Clinics were interviewed. These pregnant women (5 in number) were interviewed with the view of knowing the level of appreciation and satisfaction of health care service they were receiving. Interviews were interactive and were used in an attempt to have a deeper understanding and obtain information of the phenomenon under study [32][38].

The study period spanned 10 months, that is, from July 2014 to March 2015. Within this period two technical boot-camps were held. The first was in July 2014 and the second was in November 2014. At the first meeting the different data collection instruments such as ANC, PNC registers and Child and Maternal Health Records were reconciled and standardized to enable customization of the e-Tracker module in the DHIS2. Standardization of these documents was necessary prior to customization because of the existence of different

versions in the public health system. At this first boot-camp only the ANC register was updated to the required standard because stakeholders who were supposed to have made inputs for the updates were not present. In view of this challenge only the ANC component of the e-Tracker was developed, end-users trained and decision taken to pilot the system in one district. A number of supporting and monitoring visits were also made to the twenty-one facilities within the pilot district. Lessons learnt from these visits fed into the second technical boot-camp in November 2014. At this meeting the Delivery, PNC and FP registers were standardized and components of the Maternal and Child Health (MCH) services were programmed into the e-Tracker module. This was followed by on-site trainings conducted for end-users to enable them commence inputting 2014 MCH service data.

Amongst the 21 health facilities in the selected district, four were purposefully selected for in-depth studies [53]. Other reasons for purposefully choosing these four facilities were easy access to research sites, limited resources and the likelihood of getting the required data for analysis. These health facilities are from two sub-districts within the selected district and from each of these one HC and one CHPS compound were chosen for in-depth studies. Even though the CHPS compounds chosen were equipped with delivery wards and are supposed to be able to conduct deliveries there were no midwives due to lack of this calibre of health staff.

4.2   Data Analysis

In qualitative research data collection and analysis go hand-in-hand as field work progresses. The data collection informs the analysis and vice versa [34][35]. Field diaries were kept in which field notes were taken during interviews and when observing health staff at work. Field notes were also supplemented with photographs of health staff at work, end-users inputting data into the e-Tracker, data capturing instruments such as summary forms, registers and clients receiving MCH services. The analysis of the field notes involved transcribing and organising the notes into themes informed by the interview guide, the theoretical concepts and the research question [32][38]. These themes were on work practices, effect in the use of the e-Tracker on work flow, merits and demerits of the system, issues of the system relating to data reporting, organizational influences, socio-cultural issues and recommendations for system improvement and sustainability. Particularly the study focused on the interactions of the e-Tracker in the health domain by trying to understand the dynamics of socio-technical effects in ANT terms of translation and alignment of actors in a network, work practices, organizational influence or focus, and emergent tensions or conflicts or threats [6][8][50].

5   Findings

This section describes the CHPS concept as a vehicle for providing primary healthcare at the community level within the public health sector in Ghana. The section also highlights the activities and the workflow of the health staff as they discharge their duties in both the paper-based and the EHR systems respectively.

5.1   Providing MCH Services at the Community Level

The strategic policy of the GHS is to have a three tier level of healthcare within a district. These are the district level where we have the District Hospitals (DH), the sub-district level where we have the Health Centres (HC) and the Community level where we have the CHPS compounds. At the CHPS compound primary healthcare is provided to the population by resident CHOs who are assisted by community social structures and volunteer systems [20].

The CHPS initiative by the government of Ghana is a strategy for providing sustainable healthcare to the population in the rural communities. The basic structure for CHPS implementation is a Community Health Officer(s) (CHOs) resident in the community who serves as a representative of the GHS, the existence of active Community Health Management Committees (CHMCs) responsible for managing the CHPS compound and Community Health Volunteers (CHVs) who serve as a link between the members of the community they represent. The health service on the other hand is represented by the CHOs who are normally Community Health Nurses (CHNs) [20].

A range of services both curative and preventive are provided by the CHOs at their catchment areas. Some of these services are provided at static clinics at the CHPS compound or as outreach services in the community and households. With regards to MCH services the CHO is expected to carry out regular home visits, provide

ANC services both in the homes and the community, monitor the growth and development of children in the community, provide immunization to children and pregnant women in homes and the community, create awareness and provide appropriate FP methods to individuals and couples, conduct emergency deliveries, recognise complications in pregnancy, delivery and post-delivery and make prompt referrals. In addition the CHO is also expected to monitor the activities of Traditional Birth Attendants (TBAs) and as well as the activities of private midwives.

In pursuance of his/her duties the CHO is expected to keep stock of his/her activities by compiling and updating health service registers on ANC, Deliveries, PNC and FP. Reports on these activities are expected to be submitted on time to the district. Hence the focus of this study was on the activities of the CHOs in the performance of their duties in providing and reporting of MCH services at the point of care using the e-Tracker. These activities have been categorized into three thematic areas namely (a) Provision of Community MCH Services, (b) Continue of Care in the Community and (c) Reporting on Service/Healthcare Delivery.

5.2   Provision of Community MCH Services

The CHOs at the CHPS zones and compounds have the oversight responsibility of providing antenatal services to pregnant women and postnatal care to mothers and babies especially at the early stages of birth. This entails a number of household visitations to provide service to pregnant women, mothers and babies (or static clinics at the compound). The findings are that during pregnancy the CHO visits their clients at least each trimester to assess their health status and counsel accordingly. Where there are complications clients are referred to a higher health facility for medical attention by specialists. During these household visits pregnant women are also prepared for delivery. These preparatory stages are recorded in a booklet called 'what every pregnant woman should know'. This is provided by the MOH of which copies are given out to clients to keep.

By policy all CHPS compounds are supposed to have a midwife but this is not the case at the sites visited even though there were delivery rooms at the compounds. The findings were that this is also the case in most CHPS compounds in Ghana. This is due to lack of midwives in the sector and the few there are, are quite old and nearing their retirement age. Clients in their late pregnancies were monitored by household members and/or CHVs. At the onset of labour the CHO is informed in person or by phone who in turn notify the village/community ambulance for the expected mother to be conveyed to the HC to deliver. At the sites visited the village ambulances were privately owned motorbikes that are hired for a fee. After delivery the CHO continues the household visitations to provide postnatal care and this is intensified for the first twenty-eight days when mother and child are most vulnerable.

In the paper-based HIS ANC, PNC, Delivery and FP services are recorded in the Maternal Health Records and Child Health Records booklets which are kept by the mother. The contents of these booklets and that of the paper registers for these services are the same. At the end of every month health statistics are compiled from the registers onto paper summery forms for submission to the district for input into the DHIS2 by the district Health Information Officer (HIO). These data processing activities described above were before the implementation of the e-Tracker. But after the implementation of the system it is expected that all data collection and reporting would be done at the point-of-care electronically in the e-Tracker.

There used to be some level of collaboration between TBAs and the formal health system when it came to issues concerning MCH, especially deliveries. With support from stakeholders such as the UNFPA, in the past TBAs were trained to assist the health facilities to provide supervised delivery in order to reduce maternal mortality and improve maternal health [46]. Somewhere in the mid-2000s this partnership was abrogated by the MOH and currently TBAs are not by policy recognized as caregivers in the communities any longer when it comes to MCH issues especially deliveries. The situation is somewhat blurred at the sites where this study was conducted because there seems to be some semblance of cooperation between the health facilities and the TBAs.

5.3   Continuum of Care at the Community Level

The CHPS compounds provide both static and outreach services to the population in their respective catchment areas. In the event that clients were absent from scheduled ANC, PNC and Child Welfare Clinics (CWC) the findings were that the CHOs followed-up to find out the reasons for the client's absence. Sometimes these follow-ups were done through the CHVs or through members of the CHMC in situations where the CHO was engaged and cannot perform this service in person. With the advent and proliferation of mobile phones follow-

up on clients were also done if their contact numbers or those of next of kin were known. This is to ensure continuous care to mother and child. For instance, this continued care will ensure that the children are immunized and protected against all immunizable childhood diseases. Furthermore in situations where clients are referred to the health centre the CHO at the CHPS compound follows-up to ascertain whether clients indeed went to the facility for medical attention.

5.4   Data Reporting on Service Delivery

Every service provided at a health facility generates data that is supposed to be used for planning and making decisions for providing healthcare. At the community level different data-collection instruments were used to record MCH services provided. The findings were that every pregnant woman receiving ANC service for the first time was provided with a Maternal Health Records (MHR) booklet which contains all the information on the pregnant woman from ANC through Delivery to PNC and FP. This booklet contains information on personal history, demographics, obstetric history, medical/surgical history, etc. This booklet is kept by the client and has to be presented whenever she accesses health service at a health facility.

After delivery a similar booklet called Child Health Records (CHR) is given to the child and it contains information on the child, i.e. demographics of the child and the mother, immunization history, growth monitoring chart, breast feeding, management of malaria, information on FP for the parents, etc. This booklet has to be presented by the mother anytime the child accesses health service at a health facility. At the facility level the CHO at the CHPS compound keeps registers on ANC, PNC, CWC and FP services provided. Similarly, the midwife at the HC keeps a register on Deliveries at the facility. These registers contain information on individual clients who have accessed service at the facility and have information similar to that in the MHR and CHR booklets. According to the care givers data from these registers are aggregated on summary sheets and physically sent to the district for input by the district HIO into the DHIS2 database.

The observation at the research sites was that there were disparities in some of these data collection instruments. For instance even though MHR booklets looked the same there were differences in naming of some of the fields e.g. for personal history for the client one field is named location in some and community in others; FP field in some but FP field missing in others. For the registers and monthly summary sheets there were also marked differences in the naming conventions and the number of indicators in these data collection instruments. The reason attributed to this apparent lack of standardization was that the instruments are updated periodically but the updated versions do not get to the facilities on time to be used. Faced with a situation the CHOs said they have to improvise using the old ones where pencil is used to correct the names of the indicators or data elements in question. Such practices obviously have serious implications on the quality of data being reported.

5.5   Implementation of the e-Tracker

The HIS in Ghana is a combination of both paper and electronic. Data is compiled at the point of generation on summary sheets and submitted to the district for input into the DHIS2. Over the years a number of challenges have been identified in the provision and reporting of healthcare services at the facilities. As have been identified in other IS researches some of the reasons for perceived challenges in health data reporting are lack of skilled manpower in data management, lack of standardized data collection instruments, poor infrastructure, lack of resources, etc., and the same can be said about the situation in Ghana [8][23][30]. Recent developments in IT infrastructure in Ghana has lend impetus to scaling the DHIS2 to the community level with the aim of using ICT to support the provision and reporting of healthcare services at that level.

The e-Tracker is an individual client-based EHR system designed to capture data on ANC, Delivery, PNC and FP services provided at a given health facility. It is an inscription of the processes and data attributes in the paper-based system in an electronic format. It also has other additional functionalities to facilitate provision of healthcare and reporting. These functionalities are registration of client demographic data, scheduling client encounters, tracking client progress over time in accessing healthcare, following-up on healthcare defaulters, collating individual data into aggregates for the DHIS2, performing different analysis, and generating different reports. A client (for example a pregnant woman) reporting at a health facility for healthcare is first registered in the system. The demographic data comprising of name, address, gender, age, phone number, next of kin, etc. constitute the registration data attributes.

After this input the registered client could then enrol in any of the MCH programmes, that is, ANC, PNC and FP. To follow a pregnant woman through ANC the system requires the woman to provide the Last Menstrual Period (LMP) date which will be used by the system to automatically calculate the next and subsequent ANC visits. To search for clients, the e-Tracker's search engine uses different criteria based on unique identifier, name, address, date-of-birth, phone number and/or a combination of these. Most Ghanaians have enrolled in the National Health Insurance Scheme (NHIS) and have unique NHIS number. This is used as a unique identifier in the e-tracker if a client has it. Otherwise a system generated identity number for every registered client is used as the unique identity number.

With these sterling characteristics it was envisaged that implementation of the e-Tracker at the CHPS compounds/zones will facilitate provision of healthcare, address challenges in MCH data reporting and scale the DHIS2 to the community level. It was for this background that a two weeks boot-camp was held in July 2014 to design the system and to train end-users on its use. With support from the University of Oslo DHIS2 the technical team at the GHS undertook the customization of the e-Tracker. Healthcare officers from the Family Health (FH) Division also assisted in standardizing the data collection instruments before incorporation into the e-Tracker. This is because MCH services are under the purview of the FH division of the GHS. Because of data overlaps some indicators and data elements needed further clarification and redefinition before input into the e-Tracker.

Figure 1. E-Tracker Training Session

After this technical work end-users from the pilot district were trained for two days in the use of the system with live data input for 2014. Those trained consisted of the District Director of Health Services (DDHS), District Public Health Nurse (DPHN), Heads of sub-districts, all heads/in-charges of health facilities in the district, all Community Health Nurses (CHNs) at the various CHPS compounds/zones and some midwives.

5.6   Learning Experiences from the e-Tracker Implementation

Facilities were asked to enter 2014 data to test the functionality of the system and followed-up field visits to selected sites yielded some positive comments. All the sites visited were of the accord that the system was quite efficient for record keeping and data management. This in their view was because, compared to the paper system it was easier to retrieve and manage records in the e-Tracker. In terms of archiving users said that it ensures good storage and retention of data and reduces the possibility of losing data. Users further said that with the paper system it is easy to lose data. Users were also of the view that the e-Tracker promotes data transparency and directly ensures that users input correct data in lieu of which peers and superiors are likely to question any spurious data in the system.

At the community level care givers were of the view that the system was particularly useful in scheduling client encounters and following-up on clients to ensure continuity of care especially where there happens to be defaulting clients. When asked what were the merits and demerits of the e-Tracker, some of the responses were:

'.. it is a good system because it keeps all the data at one place and when we need it we can just open the system and get it…with the paper system it is possible to lose the data when you cannot find the paper'

'.. with this system everybody sees the data when it is captured in the system, this means one has to be careful to input the correct data'

'..the system makes it possible to see which pregnant woman has defaulted in coming to the facility for MCH services…when this happens we can follow-up on the defaulter to find out what was the reason'

'..the only problem with the system is using it at the point of care especially when you are few….this is because we do many things at the same time and it makes service delivery very slow…and also because the keys on the tablet computer are very small and difficult to operate when under pressure'

Above all the e-Tracker was said to be quite user-friendly and could eliminate the monthly trips to the district office for submission of paper reports as these trips also have budget implications and are sometimes inconvenient. Furthermore, the e-Tracker could shorten the hither-to data flow from points of generation in the communities to the next level thereby reducing some of the potential complexities which may lead to data quality challenges.

Despite the good characteristics of the e-Tracker, users reckoned a number of challenges which needed to be addressed for its smooth running and scaling-up. The CHOs complained about the workload, that is, combining provision of healthcare and data management was particularly challenging when one considers the staff strength for MCH services. In fact care givers interviewed said that they were finding it increasing difficult to offer healthcare, complete all paper works (fill out registers, MHRs and CHRs) and then enter data into the e-Tracker. This was found to be true because as at the times of the visits, that is, September 2014, November 2014 and January 2015, none of the facilities visited had completed 2014 entries in the e-Tracker. Users therefore suggested that it would be ideal to increase the staff strength at the facilities with one person responsible for data management. Otherwise it may be impossible to provide healthcare and simultaneously manage the e-Tracker at point-of-care.
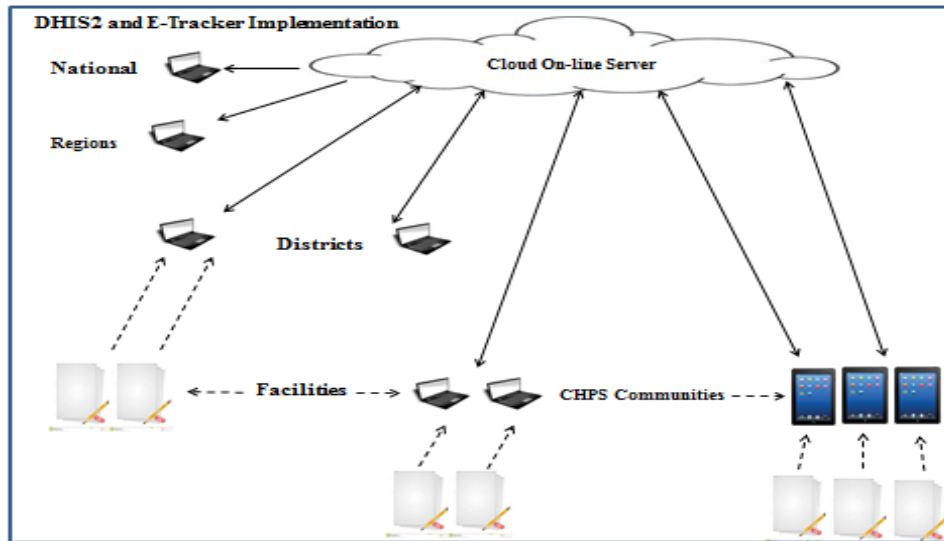
Figure 2. DHIS2 and E-Tracker Implementation in Ghana
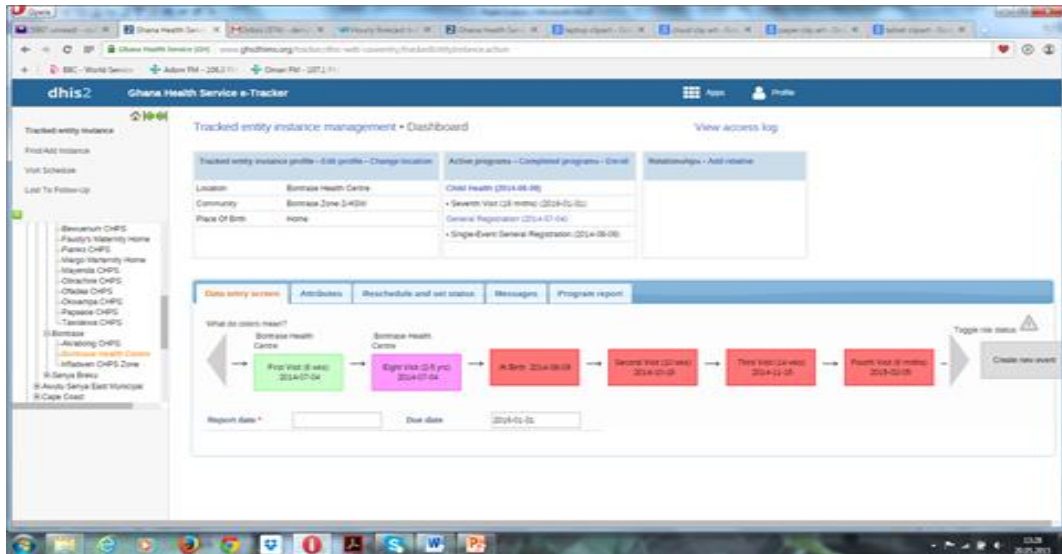
Figure 3. E-tracker Dashboard of a Child/client Enrolled in Child Welfare Programme

For example one scenario sited by a CHO was a comment passed by a client when the CHO was concurrently offering ANC service and entering data in the e-Tracker:

'What is wrong with these nurses these days? Look at this one! Instead of concentrating on her job she is all the time looking at her mobile phone and wasting our time here.'

After this comment the CHO had no option but to stop her data entering and concentrated on providing ANC service! It was also obvious that no sensitization was done to orient clients on the new electronic system.

The CHW(s) were then asked how they were able to capture data into the system because the initial arrangement was to capture data simultaneously at point-of-care. The response was;

'We are only two here and MCH work entails a lot and at the same time we do other clinical work like attending to OPD. So the only time we are able to get data into the system is when the tension has gone down and that is in our free time. Sometimes it's only one person here when the other has to go for a workshop or travel, so it's not possible to combine taking care of clients and at the same time working on the system'

Other challenges relate to suitability of IT equipment, instability of electricity power and erratic nature of internet connection at some of the facilities. Users claim that the keys on the tablet computers were too small thus inputting data becomes somewhat cumbersome especially on very busy days. Otherwise the system is said to be technically quite easy to use. The CHOs therefore expressed the wish for laptop computers instead of the tablet computers. One of the responses concerning the use of tablet computers for service delivery and reporting was:

'...the tablet is good but not easy to use especially when there are lots of clients...we think a lap top computer will be better because one can work faster'

It was also observed that computer literacy was a challenge especially among the old CHOs and midwives. The CHOs who were trained remarked that the number of training days were insufficient to enable them master all the functionalities of the electronic system. This was because some of them who were not very computer literate found it difficult to backtrack when they got stuck in a process. Others also expressed the wish to explore additional features, especially the analytical aspects, of the system but could not for fear of causing some damage to the e-Tracker module.

6   Discussions

The previous sections have been on the account of designing and implementing the EHR system, namely the e-tracker, in health facilities to support MCH services at the community level in Ghana. An evaluation of the system in use have brought to the fore issues which might be identical to some of the issues already mentioned in the IS literature when ICT artefacts are introduced into social systems or organizations such as the health domain [6, 50]. The study looked at the complex interactive effects of the technical artefact, the e-Tracker,

with respect to the activities and actors involved in providing MCH services in rural communities in Ghana. This section analyses these complex sociotechnical effects on work practices, the health domain as an organization, and possible threats or tensions that might have emerged through this entanglement of the social and the technical.

6.1   Effects on Work practices

Activities involved in the provision of MCH and other services at the CHPS compounds/zones or community levels are to be performed by at least two to five health workers and supported by community volunteers if quality healthcare is to be provided. For ethical reasons I will name facilities by using alphabets. The staff strength at both CHPS compounds A and B visited were two respectively. At CHPS compound A there is one regular ancillary staff responsible for general cleanliness of the compound who also doubles-up as care provider. This ancillary worker at facility A have added responsibility of having to provide care and do data entry due to inadequate qualified health staff at this facility. At both facilities A and B the use of the e-Tracker for MCH services and data reporting is done retrospectively because of lack of staff to enable point-of-care use of the e-Tracker. The scenario was the same at the two health centres visited. The staff strength was low taking into consideration the size of their catchment population. The e-Tracker was being used retrospectively after service provision contrary to initial design intension.

   This low staff strength also affects outreach services and household visitations at the communities. Since the CHPS has to provide both static clinics and outreach services it means one CHW has to always be at the compound to attend to clients whilst the other embarks on outreach services. The principle of using the community social structures to support the work of the CHW to provide MCH services as was exemplified when CHPS was a research project seems to be disappearing simply because there are no remunerations or incentives for the volunteers. When the CHPS was conceptualized as a project there were remunerative packages for volunteers from the communities. But this study has observed that the volunteer component of the CHPS implementation in reality is becoming problematic because of lack of incentives possibly due to financial constraints.

   From these analyses one can infer that there has been realignment of MCH work practices at the community level as a result of introducing the e-Tracker. As a result of low staff strength at the health facilities there has been increase in the workload in general because health staffs were not being able to use the e-Tracker as a point-of-care system but had to resort to retrospective reporting [6, 50]. But in terms of designated responsibilities others have increased workload than others as in the case of the ancillary staff at CHPS facility A, who was not supposed to be assisting in MCH healthcare services. However, one can discern some degree of collaboration among the workers as they improvised in order to perform MCH activities with the introduction of the e-Tracker. Thus the introduction of the e-Tracker has occasioned the emergence of very complex interactions in the provision of the MCH services.

6.2   Effect at the Organizational Level

Studies have shown that introducing EHR into the health domain could have both positive and negative effects as has been observed in this research [6][50]. Lack of adequate staff has resulted in realignment of work and responsibilities among the few health workers at the health facilities visited. These realignments have resulted into none skilled health workers having to offer some MCH services thereby interacting with the e-Tracker. The knowledge thus acquired by these none skilled staff have direct influence on the healthcare system. These effects could be said to be positive if the acquired knowledge is applied correctly and negative otherwise.

   The design of the e-Tracker is also seen to have some effects on the delivery of MCH services. The imposition of system checks on some data elements affects the provision and recording of MCH services. For example it is mandatory to input values for last menstruation period (LMP) for ANC clients in the e-Tracker to facilitate scheduling of subsequent visits. Again the validation rules inscribed in some of the data elements in the e-Tracker prompts health workers to be more fastidious during data entry. This intrinsically makes health staff conscious of the importance of recording the correct data. This system checks essentially promote organizational learning and awareness of the essence of data quality in the health domain. The down side to organizational focus on some data elements is that health staff may not be particular about some data elements which may eventually affect some dimensions of data quality. For example data completeness and accuracy may be compromised if data entry skips some data elements because they are note tagged as mandatory.

6.3   Environmental Threats

The design and implementation of EHR system in the health domain is to leverage on perceived good characteristics of such artefacts to improve and minimize error in providing healthcare and reporting health data [14][51][52]. In pursuance of this goal research has also shown that IT artefacts behave unpredictably when introduced into social systems such as the health domain. These unpredictable interactive effects are contextual and manifest themselves in a number of ways such as errors in reporting healthcare service e.g. laboratory reports, drug dispensing, data quality challenges and so on [6][50]. Similar observations were made in this study in the area of reporting the MCH services. These in some of the IS literature are called risks or contradictions or tensions [50] and are being referred to in this study as the threats in the health environment as described below.

The data reported in the e-tracker were incomplete and this was attributed to a number of reasons. First due to lack of adequate staff and the huge workload, data was being captured after service has been provided using the various MCH paper registers as the original source instead of point-of-care data entry as originally envisaged. Hence there were some data entry backlogs when data in the MCH paper registers were reconciled with the data in the e-Tracker. Secondly there were gaps in some of the individual records in the e-Tracker. This was due to missing values for data elements without validation rules making such records incomplete and inaccurate. Thirdly, erratic electricity power distribution and unstable internet connection occasioned frequent system breakdowns leading to data entry backlogs which were difficult to clear. Lastly because of poor computer skills and also staff not properly mastering the use of the e-Tracker there were some double registrations in the system. According to the health staff sometimes they were unable to navigate themselves out of a 'fix' when stalled in data entry and have to reregister a client again. These practices occasioned double registrations as staff could not delete the uncompleted records from the system. These observed breakdowns may affect provision of healthcare and reporting of health data in significant ways. and these may therefore be seen as threats to the health domain.

7   Conclusion

This paper is about scaling an electronic health record system called the e-Tracker to the community level for the provision of maternal and child health services to the rural Ghanaian population. This is being made possible because of two reasons. One, the healthcare system in Ghana is decentralized beyond the district to the community level called the CHPS. Two, leveraging on recent ICT developments in Ghana the GHS has also decentralized the DHIS2 system (of which e-Tracker is a module) to all districts in the country using a cloud server-based architecture and hence the possibility of scaling to the community level.

This paper aims to contribute to studies in introducing sociotechnical systems to lower levels of the health domain and also to understand their interactive effects. The findings corroborate findings in earlier studies that interactive effects of actors in sociotechnical systems are complex and cannot be predetermined but are emergent in nature [6][22][50]. And to understand these effects the researcher has to follow the movement of the technical artefact as it interacts with the social domain. In this research these effects were studied through evaluating the work practices of the health workers in their use of the e-Tracker. Concepts from ANT were used as lenses to conceptualise how different realities or effects are experienced and enacted by different actors in a network [39][40].

One of the findings was the observation that there was realignment of work practices among all cadres of health workers which may have the potential of affecting provision of MCH service and reporting either negatively or positively [6][50]. Emergent undesirable sociotechnical effects as conceptualized in the IS literature as risks or tensions or contradictions were also observed and in this study called environmental threats. Some of the desirable effects observed with the introduction of the EHR were ease of use, good data storage, efficient data retrieval, proper scheduling and tracking of clients for continue of care. The import of this is that these effects cannot be predetermined but emergent because of the unpredictable and complex behaviour exhibited when technical artefacts are used in social systems. Therefore observed sociotechnical effects of artefacts in use in social systems could not be generalized because of their emergent nature and may be contextual.

Significantly the intension of completely replacing the paper system with an electronic one could be viewed as clash of standards as the two systems follow different rationalities with respect to work practices [22]. Therefore attempting to replace the paper system with an electronic system by operationalizing the

electronic system with the paper logic introduces unnecessary complexities and interdependencies which is affecting work practices as has been exemplified in this study. Rather it will be important to ensure the coexistence of the two systems (as has been the case in almost all information infrastructures thus far) by finding a middle ground such as dedicated HIOs at each service delivery point that will ensure part collection of accurate data electronically and also accurate recordings in the paper registers for later input in the e-Tracker. This harmonization and coexistence of these two systems may ensure more credible HIS and improved data quality.

Statement of conflict of interest

I will like to state that there were no conflicts of interest in the conduct of this study.

Acknowledgements

References

[1]   AbouZahr, C. & Boerma, T, 2005. Health Information Systems: the foundations of public health, Bulletin of the World Health Organization, 83(8).

[2]   Anadach Group, 2012. Nairobi conference on eHealth sees high-level participants discuss rapidly growing African eHealth platforms and say no to "pilotitis".

[3]   ATO, 2014. Africa Telecoms Outlook (ATO), 2014. Maximizing Digital Service Opportunities. *www.informatandm.com*.

[4]   Asangansi, I., & Braa, K. (2010). The Emergence of Mobile-Supported National Health Information Systems in Developing Countries *in Proceedings fromThe 13th World Congress on Medical and Health Informatics Medinfo 2010* Cape Town, South Africa.

[5]   Ash, J, Berg, M, Coiera, E, 2004. Some Unintended Consequences of Information Technology in Health Care: The Nature of Patient Care Information System-related Errors. *Journal of the American Medical Informatics Association Volume 11 Number 2 Mar / Apr 2004*.

[6]   Berg, M, 1999. Patient care information systems and healthcare work: a sociotechnical approach.   *International Journal of Medical Informatics 55 (1999) 87–101*

[7]   Berg, M, & Goorman, E, 1999. The contextual nature of medical information. *International Journal of Medical Informatics 56 (1999) 51–60*

[8]   Berg, M, 2001. Implementing information systems in healthcare organizations: myths and challenges. *International Journal of Medical Informatics 64 (2001) 143–156*

[9]   Black, A. D., Car, J., Pagliari, C., Anandan, C., Cresswell, K., Bokun, T., McKinstry, B., Procter, R., Majeed, A. & Sheikh, A., 2011.The Impact of eHealth on the Quality and Safety of Healthcare: A Systematic Overview. *PLoS Medicine*, 8,1.

[10]   Blaya, J., Fraser, H., & Holt, B., 2010. E-Health Technologies Show Promise In Developing Countries. *Health Affairs 29, NO. 2 (2010): 244–251*.

[11]   Braa, J., Monteiro, E., & Sahay, S., 2004. Networks of Action: Sustainable Health Information Systems Across   Developing Countries. *MIS Quarterly, 28*(3), 337-362

[12]   Braa, J., & Hedberg, C. (2002). The Struggle for District-Based Health Information Systems in South Africa. *The Information Society, 18*, 113-127.

[13]   Braa, J., & Sahay, S. (2012). Integrated Health Information Architecture: Power to the Users. *New Delhi: Matrix Publishers*.

[14]   Braa, J., Hanseth, O., Mohammed, W., Heywood, A., & Shaw, V. (2007). Developing Health Information Systems in Developing Countries. The "Flexible Standards" Strategy. *MIS Quarterly, 31*.

[15]   Chib A, Cheong Y.J, Lee L.C.L, Ng C.H.C, Tan C.K, Vlv K, 2012. The Hope of Mobile Phones in Indian Rural Healthcare. *Journal of Health Informatics in Developing Countries*. 2012;6(1):406-21.

[16]   Chan, M, Kazatchkine, M, Lob-Levyt, J, Obaid, T, Schweizer, J, Sidibe, M, Veneman, A, Yamad, T, 2010. Meeting the Demand for Results and Accountability: A Call for Action on Health Data from Eight Global Health Agencies. *PLoS Medicine | www.plosmedicine.org 1 January 2010 | Volume 7 | Issue 1*

[17]   Chetley, A. 2006. Improving Health, Connecting People: The Role of ICTs in the Health Sector   of Developing Countries. *InfoDev*.

[18]   Chaudhry B, Wang J, Wu S, Maglione M, Mojica W, Roth E, Morton SC, Shekelle PG, 2006. Systematic review: impact of health information technology on quality, efficiency, and costs of medical care**.** *Ann   Intern Med* 2006, **144:**742-752

[19]   Calandro, E, Gillwald, A, Moyo, M, Stork, C, 2011. Comparative ICT Sector Performance Review 2009/2010. *Towards Evidence-based ICT Policy and Regulation Volume Two, Policy Paper 5, 2010*

[20]   GHS CHPS, 2005. Community-based Health Planning and Services (CHPS). The Operational Policy. Ghana Health Service Policy Document No. 20. May 2005.

[21]   GHS CHPS Manual, 2013. Strengthening Community-based Health Planning and Services.   Manual   for Community Health Management Committee. *USAID/Ghana/JICA Project*.

[22]   Hanseth, O., & Lyytinen, K. (2010). Design theory for dynamic complexity in information infrastructures: the case of building internet. *Journal of Information Technology, 25*, 1-19. doi: 10.1057/jit.2009.19

[23]   Heeks, R, 2002. Information Systems and Developing Countries: Failure, Success, and Local Improvisation. *The Information Society, 18*, 101-112.

[24]   Tolly K, Nembaware V, Skinner D, 2011. Encouraging HIV testing through SMS: Can it work, and do content and dosage impact?. *South African AIDS Conference, Durban, South Africa*.

[25]   Germann, S., Jabry, A., Njogu, J., & Osumba, R. (2012). The Illness of "Pilotitis" In mHealth – Early Lessons from the KimMNCHip Partnerships in Kenya. *Paper presented at the Geneva Health Forum, Geneva, Switzerland*.

[26]   Ellingsen, G., & Monteiro, E. (2008). The organizing vision of integrated health information systems. *Health   Informatics Journal, 14*(3), 223-236.

[27]   MOH MAF, 2011. MDG Acceleration Framework and Country Action Plan for Maternal Health

[28]   Mechael, P., 2009. MoTECH: M-Health Ethnographic Report.

[29]   Mahmood, S, Ayub, M, 2010. Accuracy of Primary Healthcare Statistics Reported by Community Based Lady Health Workers in District Lahore. *Journal of the Pakistan Medical Association*.   2010;60(8):649-53.

[30]   Matavire , R., Chidawanyika, H., Braa, J., Nyika, P.,Katiyo, J., 2013. Shaping the Evolution of the Health Information Infrastructure in Zimbabwe. *8thHELINA 2013 Conference*.

[31]   Mechael, P, Batavia H, Kaonga N, Searle S, Kwan A, Goldberger A, Fu L, Ossman J, 2010. Barriers and Gaps . Affecting mHealth in Low and Middle Income Countries*: Center for Global Health and   Economic Development Earth Institute, Columbia University, New York*.

[32]   Miles, M.B. & Huberman, A.M. (1994). Qualitative Data Analysis. *Thousand Oaks: Sage   Publications*

[33]   Mishra, S. & Singh, I. P., 2008. m-Health: A Developing Country Perspective

[34]   Myers, M. D. (1997). Qualitative Research in Information Systems. *MISQ Discovery*. Retrieved from http://www.qual.auckland.ac.nz

[35]   Klein, H. K., & Myers, M. D. (1999). A set of principles for conducting and evaluating interpretive field studies in information systems. *MIS Quarterly, 23*(1), 67-93

[36]   Kiragga, B. Castelnuovo, P. Schaefer, T. Muwonge, J. Easterbrook, 2011. Quality of data collection in a large HIV observational clinic database in sub-Saharan Africa: implications for clinical research and audit of care. *J. Int. AIDS Soc. 14 (2011) 3*.

[37]   Kaghan, W, N, Bowker GC, 2001. Out of machine age?: complexity, sociotechnical systems and actor network theory. *Journal of Engineering and Technology Management* 2001, **18:**253-269.

[38]   Kvale, S., (2009). Learning the Craft of Qualitative Research Interviewing. Sage Publication Inc.

[39]   Latour, B, 2005. Reassembling the Social: An Introduction to Actor-Network Theory. *Oxford University Press*.

[40]   Law, J, 1992. Notes on the Theory of the Actor-Network: Ordering, Strategy and Heterogeneity**.** *Systems Practice* 1992, **5:**379-393.

[41]   Leon, N, Schneider, H, & Daviaud, E, 2011. Applying a framework for assessing the health system challenges to scaling up mHealth in South Africa. *BMC Medical Informatics and   Decision Making* 2012, **12**:123

[42]   Oluocha, T, Santas, B, Kwaroc , D, Were, M, Biondichd, P, Baileye, C, Abu-Hannaf, A, Keizer, N, 2012.   The effect of electronic medical record-based clinical decision support on HIV care in resource-   constrained settings: A systematic review. *International Journal of Medical Informatics*

[43]   Research ICT Africa, 2011. http://www.researchictafrica.net

[44]   Skinner D, Rivette U, Bloomberg C, 2007. Evaluation of use of cellphones to aid compliance with drug therapy for HIV patients**.** *AIDS Care* 2007, **19:**605-607.

[45]   Tohouri, R, 2009. Building e-Health Information Infrastructure in Mali**.** *IIMC International Information Management Corporation, 2009 ISBN: 978-1-905824-11-3*

[46]   UNFPA, 1996. Support to Traditional Birth attendants (TBAs). Issue 7

[47]   UN MDG Report, 2013. The Millennium Development Goals Report.

[48]   UN, 2007. Compendium of ICT Applications on Electronic Government. Volume 1: Mobile Applications   on Health and Learning. *IN DESA (Ed.). New York*.

[49] Unicef, 2008. Countdown to 2015:Maternal, Newborn & Child Survival. Tracking Progress in Maternal, Newborn and Child Survival: The 2008 Report. New York, UNICEF.

[50] Vikkelsø, S, 2005. Subtle Redistribution of Work, Attention and Risks: Electronic Patient   Records and Organisational Consequences. *Scandinavian Journal of Information Systems:Vol.*   *17:Iss.1,Article10*

[51] Wilson, R. (2000). Using Computers in Health Information Systems. Design and Implementation of HealthInformation Systems. *World Health Organization*

[52] Wilson, R. G. and Smith, D. L. (1991). Microcomputer Applications for Primary Healthcare in   Developing Countries. *Infectious disease clinics of North America 5(2): 247*.

[53] WHO, 2011. mHealth: new horizons for health through mobile technologies: second global survey on eHealth. *WHO, Geneva; 2011*.

[54] WHO, 2010. Antiretroviral Therapy for HIV Infection in Infants and Children: Towards Universal Access,

[55] WHO, 2013. Improving maternal and newborn access to services in Ghana. *Grameen   Foundation's MOTECH*

[56] WHO-UHC, 2013. Universal Health Coverage: Supporting Country Needs.

[57] WHO Report, 2015. Strengthening the Capacity of Community Health Workers to Deliver Care   for sexual, Reproductive, Maternal, New-born, Child and Adolescent Health. *Technical brief   by the H4+ (UNAIDS, UNFPA, UNICEF, UN Women, WHO and the World Bank)*

[58] Yin, R, 2009. 4th Edition. Case Study Research: Design and Methods. Newsbury Park, California: Sage.