Clinical informatics tools for healthcare quality improvement: a literature review

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Abstract

The paper is a review of existing literature on the importance of clinical informatics tools in promoting effective healthcare delivery. The study reports literature on clinical informatics types, benefits and challenges across the globe. The paper explains the dangers of medical errors and how clinical informatics tools can reduce medical errors, increase access to safe, effective and affordable treatment of illnesses, and promote evidence-based medicine. The paper identifies various challenges facing the use of clinical informatics in developing countries. The issues of digital divide in the use of clinical informatics tools, particularly among developed and developing countries of the world, are also discussed. The paper reveals that hospitals at various levels should embrace the use of clinical informatics tools in healthcare delivery, especially in developing countries where there are inadequate medical personnel. The paper has the potential to inform policy makers, improve practice and contribute to research in the area of social informatics.

Keywords: clinical informatics, clinical informatics tools, healthcare, quality, literature review

Introduction

Clinical informatics is the integration of clinical science, computer science and information science to manage and communicate data for clinical practice. Polašek and Kern (2012) define clinical informatics as the application of information communication and technology in all areas of medicine. The essence of clinical informatics is to promote the integration of data, information, knowledge and wisdom to support the decision-making process of medical doctors, patients and other healthcare professionals, and to promote evidence.

In addition, clinical informatics tools are the resources that enable medical doctors to effectively capture, transmit, and adequately use data and ICT knowledge to promote healthcare delivery. The tools facilitate the integration of ICT to support patients and medical doctors in decision making and at the same time promote evidence-based medicine. The American Medical Informatics Association (2018) categorises clinical informatics tools into the following: clinical decision support, clinical information systems, visual images which include radiological, pathological, dermatological, and ophthalmological images. The other types include: dental informatics, implementation and optimisation community, nursing informatics, pharmacy informatics, primary care informatics, computerized physician order entry (CPOE), computerized

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decision support system (CDSS), diagnosis image archiving (DIA) and electronic medical record (EMR) (The American Medical Informatics Associations 2018).

Clinical informatics tools are becoming an increasingly important aspect of medical practice, and it has contributed significantly to healthcare development at all levels. The adoption of clinical informatics tools promises several significant benefits, such as time management and better healthcare service. Serious unintended consequences from the non-implementation of these facilities have emerged, particularly in developing countries (Owolabi 2017).

Information and communication technologies have changed the ways and manners health professionals deliver services to their patients. Governments are leveraging ICT in healthcare in order to respond to calls by World Health organization (WHO), that every country should integrate ICT in their health care deliveries (Commonwealth of Australia 2007). In 2005, the World Summit on the Information Society (WSIS) reiterated the importance of access to effective healthcare through use of clinical informatics tools (WSIS 2005). Despite this, medical doctors' inadequate access to, and use of these clinical informatics tools, prevent medical doctors from rendering effective healthcare services.

In addition, inadequate access to and use of clinical informatics tools among medical doctors have brought about medical errors and mis-diagnoses. A review of literature reveals that no comprehensive study has been done on the use of clinical informatics tools in Africa (Owolabi 2017). Studies mainly focused on the use of Internet and computers among medical doctors (Cline and Luiz 2013; Nwargu and Adio 2013; Ruxwana *et al*. 2010; Idowu *et al*. 2008). This review is premised on this gap and provides insightful literature on the usefulness of clinical informatics tools for effective healthcare delivery. The review will focus on the following: clinical informatics tools, computerized physician order entry (CPOE), computerized decision support system (CDSS), diagnosis image archiving (DIA) and electronic medical record (EMR).Even though these tools are designed to support evidence-based medicine, many doctors still either do not have access to these tools or are not familiar with the use of the tools (Owolabi 2017).

To conduct this review, Webster and Watson's (2002) approach was employed. The approach suggested the following when conducting research on systematic literature review, particularly on the health-related research: (1) the need to use the keyword to search from relevant databases, (2) selection of relevant publications with matching criteria and (3) intensive reading to identity relevant publications. The literature search for the study was undertaken in a five-month period, from June to October 2016. Relevant literature has been added in order to update the study. For the purposes of the review, the SCOPUS, EBSCO Host and Google Scholar databases were used for relevant document retrieval. Various search strings were used to get relevant information from the databases, which include: clinical informatics, health information technology and e-health. Searches were limited to publications in English. The review is organised as follows:

Theoretical background

There are many theories relevant to a study of user acceptance of ICT. Many of these theories focus on people's intention to engage in a particular behaviour (i.e. adoption and use of ICT) as a relevant conceptual framework. Moreover, the growing rate of the use of information and communication technology, in various healthcare facilities around the globe, has led to the recognition of technology acceptance as an important issue, in the implementation of technology, in healthcare facilities (Hu *et al*. 1999: Sun *et al*. 2013).

Olasina (2014) notes that research on information and communication technologies has been informed by a number of theories which include: Theory of Reasoned Action (TRA) (Fishbein and Ajzen 1975), The Theory of Planned Behaviour (TPB) (Ajzen, 1991), The Technology Acceptance Model (TAM) (Davis 1989), The Combined-TAM-TPB (Taylor and Todd 1995) and The Model of PC Utilization (MPCU) (Thompson, Higgins, and Howell 1991)

This review is largely informed by the use of the Unified Theory of Acceptance and Use of Technology (UTAUT). The Unified Theory of Acceptance and Use of Technology (UTAUT) is a user acceptance model that was introduced by Venkatesh *et al*. in 2003. The study introduces a model that examines people's intention to use technology and adoption behaviours. According to Venkatesh *et al*. (2003) one of the reasons for creating a unified theory was to make it easier and simpler for researchers to select a theory without necessarily using references or contributing to other theories. The UTAUT condensed the thirty two variables found in the existing eight models into four main effects and four moderating factors (Ventakesh *et al*. 2003:467). The combination of the existing constructs has increased the UTAUT predictive efficiency to 70%, which is a major improvement over the previous TAM theory (Oye, Lahal and Rahim 2012).

The UTAUT theory identifies four key constructs that directly determine user acceptance and usage of technology. These are Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI) and Facilitating Conditions (FC), and four control variables, namely gender, age, experience, and voluntariness of use (Liu 2013).

Performance expectancy is about the perceived benefits a user believes will be gained from using the technology in his or her job, either to improve productivity or the quality of services (Cohen, Bancillion and Jones 2013). Venkatesh *et al*. (2003) describe performance expectancy as the degree to which an individual believes that using ICT would assist him or her with achieving better results. The effect of performance expectancy can be seen as the most salient factor, in medical doctors' acceptance of clinical informatics usage.

Effort expectancy is "the degree of ease associated with the use of a system" (Venkatesh *et al*. 2003). Effort expectancy can be described as the degree of ease of access and use of technology (Venkatesh *et al*. 2003). Almulhey (2015) notes that medical doctors' impression of clinical informatics is one of the factors that determine its use. They further argue that, attitude and ease of use of clinical informatics would also determine its use \

Social influence can be described as the extent to which an individual places importance on others' belief that he or she should use (or not use) a new technology (Venkatesh and Davis 2000). Venkatesh *et al*. (2003) describe social influence as the extent to which an individual allows the opinions of others to influence his/her decision to use a system. Studies have shown that, an individual's intention to use a new technology can be influenced by the views, opinions and perceptions of the people around him or her, particularly in his/ her immediate environment (Venkatesh and Davis 2000).

A facilitating condition is an individual's belief regarding the existence of adequate technical infrastructure as well as management policies and other internal support mechanisms that will encourage the use of the technology (Venkatesh *et al*. 2003). Facilitating conditions refer to the degree to which users believe that organisational and technical infrastructure will support the use of Information and Communication Technology (Venkatesh *et al*. 2003). Holden and Karsh (2010) note that facilitating conditions are very important in the acceptance of technology in healthcare. They observe that the availability of resources, which include technical knowledge and adequate knowledge of computers, are some of the facilitating conditions that promote the use of clinical informatics. Kijasanatoyin *et al*. (2009) likewise note that, facilitating conditions are very important in medical doctors' acceptance of clinical informatics because they are a factor that significantly explains technology use. In the next section we discuss the purposes of clinical informatics.

Purposes of using clinical informatics tools

There are many reasons why medical doctors use clinical informatics tools in hospitals. Verbeke, Karaka and Nyssen (2013) list the various reasons for using clinical informatics tools in healthcare delivery. These reasons include: provision of access to clinical informatics,

knowledge sharing, and improvement of effective healthcare delivery and management of diseases (Deniris and Kneale 2015).The purposes are discussed below.

Provision of access to clinical information

Medical practice has always been described as information-intensive profession and the integration of ICT into the profession is a great advantage, since there are many attendant developments in healthcare delivery, which include the promotion of effective healthcare delivery system. In addition, access to medical information provides medical doctors with new tools to work with, and the opportunity to practice modern day medicine. Shabi, Kuteyi, Odewale and Shabi (2008) list various types of information that medical doctors need. They include: drug information, professional development information, government regulation on medicine, routine patient care, practice organisation and management, diseases' specification information, and new medical information.

Furthermore, there are various ways in which medical doctors seek information. These include: citing professional colleagues, medical texts, the Internet, medical databases, printed journal, courses, conferences and libraries. Krueger (2010) reveals that, out of 8 million people that used the Internet in the USA, in 2004, 66% admitted using the Internet for online health information while in 2009; 24 million Americans reported the same. Sandefer, Khaira, Piceckicsand Speedie (2015) report that over 50% of the hospitals have patient portals, which has promoted effective healthcare. From this, it can be deduced that access to health information on the net has bridged distance barrier by providing access to clinical information knowledge and professional advice to patients at little or no cost. It has also reduced communication gap between medical doctors and patients.

Knowledge sharing

The concept of knowledge sharing has no universal acceptable definition (Fari and Ocholla 2015). Knowledge sharing is the exchange of knowledge between individuals, where one is communicating knowledge and the other is assimilating knowledge(Argyres, Bercovitz, and Mayer 2007).The knowledge or information that is exchanged can be in the form of ideas, results, opinions, and discoveries.

Medical doctors are knowledge-intensive professionals. As the most important group working in hospitals (Berghout, Fabbricotti and Buljac-samardzk 2017), their decisions are usually based on their knowledge and experience. Consequently, their practical and theoretical knowledge are very important in making clinical decisions about the care of patients. Knowledge sharing, in the medical discipline, particularly the sharing of findings and results with young medical doctors, would improve the effectiveness and quality of healthcare and promote collaboration, encourage the ease and timely exchange of medical information and help to reduce medical errors. Udousoro (2014) points out that access to clinical informatics tools by medical doctors assist them to disseminate and share knowledge across borders. With effective knowledge sharing, a medical doctor can send a medical report of his or her patient to a leading expert in another country who can provide advice.

Knowledge sharing, among medical doctors, could bring about improved healthcare delivery, exchange of experiences, ideas, and co-operation, in a knowledge intensive organisation like medicine. Supporting this viewpoint, Cooper, Gelb, Rim, Hawkin, Rodriguez and Prolonec (2012) admit that knowledge sharing among medical doctors is very important for effective healthcare delivery to patients, and that the quality of specialty-based clinical practices is a major determinant for patients' use of medical services. Teaching hospitals, as accredited hospitals for teaching medical doctors and at the same time being the most sophisticated form of hospital institutions, have a paramount need for knowledge sharing among their medical doctors because of the nature of their work, which involves teaching, research and practice.

Effective use of clinical informatics in knowledge sharing, among medical doctors, is a crucial means of improving their competencies and assisting them in decision making. In addition, knowledge sharing among medical doctors has a lot of benefits, particularly towards improving the quality of healthcare delivery.

Improvement of effective healthcare delivery

The quality of healthcare delivery in a country is a function of the level of access to, and use of clinical informatics tools, by the country's health system because they are necessary tools for effective diagnosis, treatment, monitoring and disease surveillance. Supporting this, Olatokun and Adeboye (2009) acknowledge that clinical informatics has become an indispensable tool for reducing diseases and ailments and has provided the Nigerian healthcare system with unprecedented opportunities to meet vital developmental goals, such as poverty reduction and provision of effective medical services.

Clinical informatics tools are continually viewed as having the opportunity to provide solutions to challenges facing the health sector. Disease control and surveillance, disease prevention, patient management and diagnosis, and health information are some of the necessary components of healthcare delivery. The appropriate use of clinical informatics tools in hospitals enhances the quality of research and promotes better healthcare service delivery by medical doctors. It can be said that access to clinical informatics tools provides up-to-date information to support medical doctors' knowledge.

Extant literature indicates that clinical informatics tools can be used to educate and create awareness of various causes of early death and ways in which people, mostly patients with chronic diseases, can perform self-examination.

Management of diseases

There are a lot of health challenges in Africa where diseases such as HIV/AIDS, malaria, cholera, typhoid, yellow fever, obesity and renal failure have been reported to have killed several people. According to the World Health Organisation (WHO) (2015), in the year 2014, 70% of the people that are infected with HIV/AIDS were living in Africa. It becomes imperative to point out the fact that, clinical informatics has the potential to provide solutions to some of these challenges, in the healthcare sectors in Africa. It needs to be noted that many developed countries such as United State of America and United Kingdom have been employing clinical informatics to manage and diagnose diseases for years. Glden (2011) and Stocwell and Filks (2013) highlight the fact that clinical informatics tools can be used to manage diseases through improved clinical outcomes, self-monitoring of health conditions, the use of vaccination and improved medication adherence.

ICT use in healthcare has contributed tremendously to helping medical doctors engage in distant consultation and diagnosis as well as gaining access to medical information for decision making. ICT tools, such as radio and television, have been very useful in disease prevention and control of epidemic in many African countries (Litho 2007). The author explains further that mobile phones, e-mail and Internet can be used for health alerts to people and medical doctors. Likewise, Bowles Dykes and Demiris (2015) identify various ways in which clinical informatics can be used to manage diseases. These include: telemedicine technologies, homecare monitoring health devices, and evidence-based technologies.

Explaining, the importance of clinical informatics tools, Wang, Fau, Allgri, Brenner and Kalmus (2015) note that 80% of healthcare expenditures, in Africa is due to the management of chronic diseases. The report affirms that, clinical informatics tools will dramatically reduce the costs of disease management and improve the quality of healthcare delivery in Africa. Appropriate healthcare support and provision of adequate clinical informatics tools in healthcare

services are cost effective and provide sustainable development to healthcare, not only in remote areas but also in cities. In the next section we discuss the types of clinical informatics.

Type of clinical informatics tools

Castaneda *et al.* (2015) categorise clinical informatics tools into the following types Computerised physician order entry (CPOE), Computerized decision support system. Diagnosis image archiving and Electronic medical record (EMR)

Computerised physician order entry (CPOE)

Jung (2006:10) describes computerized physician order entry (CPOE) as 'a prescription ordering system that allows physicians to enter an order for a medication and clinical laboratory, or radiology test, directly into a computer instead of writing it out by hand, which can cause medication errors'. The Agency for Healthcare Research and Quality (2015) defines CPOE as 'the use of computers by medical doctors to directly make orders electronically for patients'. This method is to replace traditional ways of making orders which is through paper, pen, verbal communication, phones and fax.

Based on this, CPOE is the process by which medical doctors, or other professionals, in healthcare make direct orders of medication, from a computer, with the intention of reducing errors associated with bad handwriting. With CPOE, doctors can employ the use of computer technology to make orders directly for patients' medication. The order is documented in a digital format. From these definitions, there are some salient features that should be noted; that it is only the medical doctors that can make order. The order must be done through a computer interface and must be done in a standardised format.

Computerised physician order entry (CPOE) has been contributing to the development of healthcare delivery in the following ways: reduction of errors, paying attention to patients' safety, improving the quality of healthcare and bringing innovation to effective healthcare. Khanna and Yen (2014) observe that CPOE has contributed to the improvement of medication ordering, particularly in teaching hospitals. From this, CPOE can be seen as a system basically designed for medical doctors to search for information about drug usage and adverse interactions for the treatment of patients in hospitals.

With the introduction of CPOE to healthcare, the problem of illegible handwriting and transcription errors would be a thing of the past. They argue further that CPOE would also improve the response rate of medical doctors and there will be accuracy of information about the medical history of patients (Berghout *et al*. 2017).

Computerised decision support system

Clinical informatics resources are designed to improve and assist medical doctors with making informed decisions about their patients. In an era that relies on accurate and timely information, one of the ICTs that assist medical doctors with decision making is the computerized decision support system (CDSS). Kawamoto, Houlihan, Balas, and Lobach (2005:16) describe computerized decision support system as 'any 'electronic system designed to aid directly with clinical decision making'. Pope, Halford,Turnbell, Pirchard and May (2013) describe CDSS as a computer technology programme designed with the intention to assist clinical personnel, through the combination of professional knowledge, with the use of an algorithmic rule which directs medical doctors in their decision making. CDSS is a computer application used by medical doctors, to assist them with diagnostic and therapeutic decision making in the management of patients' health. Oshroff *et al*. (2007) list various examples of CDSS to include: hand-held computer, computer, smart phone, barcode, and automated drug delivery systems. The technology is designed to improve the healthcare delivery system and reduce costs.

CDSS can be grouped into two categories: the knowledge based and the non-knowledge based. Chang *et al.* (2011) note that knowledge based CDSS can be classified into three forms, which are: the knowledge base, the reasoning engine and a mechanism which is used to communicate with the healthcare user.

CDSS has been implemented in the following areas of medicine: pharmacy, pharmacology and pathology. CDSS is used to assess renal failure, pregnancy, drug allergy and other medication related conditions (Castanedo *et al*. 2015).Uzoka, Osuji and Okure-Obot (2011) list various ways in which computer decision support systems have been found useful in medical practices. These are referral practices, managing clinical complexity, cost controls, supporting clinical diagnosis, evidence-based medicine, standardisation of practices and generally improving healthcare efficiency. From this, it can be summed up that, the major benefits of CDSS system is to support decision making for medical doctors and other allied workers, with various research evidence to inform their decisions.

Diagnosis image archiving

Diagnosis image archiving (DIA) has revolutionised the provision of radiological services in healthcare service delivery because these medical images are now converted from static paper formats to dynamic electronic formats. Diagnosis image archiving is a clinical informatics tool that can transport and store radiographic image such as magnetic resonance imaging (MRI) and computerized axial tomography scan (Weatherburn, Brayan, Nichollas and Cock 2000). DIA is a form of information and communication technology that can be purposely used for a short or long period of time for storage, retrieval, management and distribution of medical images.

In addition, it can be described as an electronic and filmless information system that is used for acquiring, sorting and displaying medical imageries electronically. The DIA has been used for archival, migration, and display of digital images, which have brought about expedite image-based workflow (Dandu 2008).

The storage of DIA can be classified as online, near line and offline. Online storage is about data storage on magnetic discs and redundant array of inexpensive discs (RAID) systems which provide access to data, in a few milliseconds. Images that do not require immediate access are stored in near line storage while offline are storage devices used for long–term storage (Dandu 2008). DIA is the only technology which provides a centralised repository for all imaging data and at the same time delivers diagnostics images such as x-rays, CT scans, MRI scans and radiology reports electronically to medical doctors at the point of care (Hains, Georgious and Westbrook 2012).

The application of ICT, for purposes of storage, retrieval and distribution of medical images, will be useful for medical doctors to support clinical examinations before making decisions. DIA machines are X-ray machines, computerised tomography, magnetic resonance and scanning machine.

The importance of DIA in hospitals where radiographic images are commonly used is to assist in the diagnosis, and management of patients in accident and emergency units. Hains, Georgious and Westbrook (2012) note that, the failure of medical doctors to employ the use of DIA, in accident and emergency units, has brought about an increase in medical errors from 0.6% to 7% in US hospitals. Access to DIA assists patients in the proper management of their health conditions. The use of DIA will create the opportunity to bridge the knowledge-performance gap for medical doctors because it will give them access to various visual information sources that will assist them in making clinical decisions as a result of increased job performance, reduced medical errors, improved accuracy and provision of opportunity for timely and reliable information. Hains *et al*. (2012) state some advantages of DIA as the provision of reliable image storage, access to information as well as permanent storage of information.

Electronic medical record (EMR)

The review of literature on electronic medical records (EMRs) has revealed a number of several definitions arising from various scholars coming from different medical fields (Hayrinen *et al*. 2008). According to the report of e-health Stakeholder (2013) electronic medical record (EMR) is a comprehensive medical record or similar documentation of the past and present physical and mental state of health of an individual, in electronic form, and providing for ready availability of these data for medical treatment and other closely related purposes. Hochwaster,Cuongm, Chuc and Lassen (2014) define EMR as a repository of health user data in digital form, which is stored and exchanged securely, and accessible by multiple authorised users. It has retrospective, concurrent and prospective information, and its primary purpose is to support effective healthcare. From these definitions, the major functions of EMR is to provide adequate information for medical doctors and other allied workers, in making medical decisions; and for hospital management, in decision making on policies.

The introduction of EMR system promotes an increase in effective healthcare delivery, improved quality of care as well as patients' and doctors' satisfaction .For example, Jha *et al*. (2009) studied the use of EMR in USA hospitals, 63.1% of the country hospitals responded to the survey and found that: 1.5% of U.S. healthcare facilities had comprehensive electronic health records; that the facility was present in all the clinical departments and that, 7.6% had a partial EMR system.

In a similar study, Hillestad, Bigelow, Baren, Girosi, Meili, and Taylors (2005) reveal that 4% of U.S. medical doctors were using EMR effectively, while between 15-20 % were using partial forms of computerised record-keeping. Hsiao and Hing (2014) report the findings of a study on the use of EMR in U.S in 2006. The results reveal that 17% of medical doctors used it in their offices; 31% claimed that they used it in emergency rooms; and 29% stated that they used it in outpatients' departments. They further reported that, in the year 2013, 78% of medical doctors used EMR in their hospitals. The reasons for this may not be far from the submission of Miller and Sim (2004) and Silo–Carrol, Edward and Rodin (2013) that, many medical doctors are ready to adopt EMR because they believe it will enhance their job descriptions.

In addition, Jha (2011) lists various types of EMR systems, which include electronic prescription, electronic health information exchange, electronic reporting of data, electronic recording of patients' medical history and clinical decision support resources. Zandieh *et al*. (2008) highlight the advantages of EMR to include the following: improved communication, provision of access to information about patients and generation of funds for healthcare facilities. If properly adopted, EMR will bring improvement to healthcare delivery and the quality of services in the hospitals.

However, Hubner, Liebe, Egberit and Frey (2012) claim that only 22.6% of German hospitals have implemented the electronic medical record system. This poor adoption rate can be attributed to high cost of clinical informatics tools. However, for any meaningful advantage to come from the use of EMR in hospitals, medical doctors are the deciding factors.Tiernney, Achieng, Baker, Biodich, Kayiwa, Mamlin, Musinquzi, Kayiwa and Yeung (2010) conducted a study on EMR in three East African countries: Kenya, Tanzania and Uganda using Open Medical Record System (MRS). The results reveal that EMR implementations were successful in the three countries. South African government introduced the EMR project in 2002 as part of its e-Health strategy introduced by the National Department of South Africa (Kleynhans 2011).

Examining the need for EMR in Nigeria's healthcare system, Benson (2011) recommends the following: the need for adequate planning, the need for medical doctors to have adequate knowledge on how to operate the system and the objectives of the introduction of the system must be maintained, which is to improve patients' safety and provide a high level of information security. What then are the challenges of accessing clinical informatics?

Challenges to access and use of clinical informatics tools

There are several obstacles facing the access and use of clinical informatics tools in many African countries. Idowu *et al*. (2008) categorise the problems into three: the people, government and ICT infrastructure. Simbia (2004) states that, poor access to ICT, poor government attitude, lack of political will and poor data quality are some of the problems facing the use of clinical informatics in African countries. The challenges facing the development of clinical informatics, in Nigeria and South Africa, are discussed in the next section.

Poor access to telecommunication

Telecommunication services are very important for effective operations of clinical informatics tools. Its role, in effective healthcare system, cannot be over emphasised. It is in support of this, that Coiera (2006) lists various telecommunication modes necessary for effective utilisation of clinical informatics tools: integrated telecommunication technology, interactive notification, interactive mode security protocol and a host of others.

However, in many African countries, there is limitation to broadband access. In countries where it is available, it is very expensive for the people. The poor ICT infrastructure status, in many African countries, has made it impossible to effectively allow the healthcare sector to benefit from the opportunity of ICT use in healthcare delivery. Lintho (2010) reveals that due to poor ICT facilities in the continent, very few hospitals are connected to the Internet and many of them have limited access. Internet World Stats (2016) affirms that most countries in Africa are not well connected to the Internet. For example, only 29.6% of the households in Ghana are connected; South Africa claims 52.6%; Angola, 37.3%; Kenya, 68.4%; and Nigeria, 5%. The statistics has revealed that many African countries have problems with inadequate telecommunication facilities, Nigeria and South Africa inclusive.

Poor access to ICT by medical doctors can be traced to inadequate telecommunication services, in Nigeria and South Africa. Though, these countries were rated high in the telecommunication sector as the fastest growing economies, it is glaring that this applies solely to the use of mobile phones. Majority of the health institutions in the two countries have poor access to broadband facilities (Idowu 2008). Kim, Kelly and Raja (2010) note that every 10% point increase in broadband services, particularly in health sector, will lead to an increase in the productivity of medical doctors and other health workers with 1.3%. This indicates the importance of increase in broadband, in clinical informatics. The resource is necessary in operating various clinical informatics tools. From the foregoing, it can be deduced that there is need for adequate broadband facilities for effective diagnosis and reduction in medical errors in African countries.

Resistance to new technology

Technology is meant to improve efficiency, accuracy and productivity. However, technology resistance is a way by which people resist the changes brought about by technology, particularly, when people are faced with new innovation or change (Fagerberg and Stholec, 2009). Idowu *et al*. (2008) note that introduction of innovation or technology may be welcomed with mixed feelings by users.

Medical doctors may resist the introduction of a technology that they believe will have negative impact on their jobs. Idowu *et al*. (2008) and Abdullai and Haruna (2008) list various reasons why medical doctors may resist the adoption of clinical informatics tools, in medical practices. Their resistance may be a reaction to new knowledge, skills and training on how to use the new technology, as well as the tendency of increase in job functions. In addition, people may resist the introduction of new technology/technologies because they may be afraid of job loss, due to reduction of staff. As a result of this, there is need for the government to build confidence

in hospital workers, before introducing the technologies and map out ways to train the hospital staff on how to use them, rather than lay staff off (Zheng 2004).

Poor ICT skills

In this era of ICT, it is very necessary for medical doctors to use the computer and other ICT components for their job performances. Anderson, Asher andWhitler, (2007) note that medical doctors need to possess the following skills, apart from their academic and professional qualifications: computer operating system, use of application software packages, knowledge of databases and medical tools automation, and technical skills. However, the potentials of ICT has not been fully utilised in many developing countries because of poor ICT skills among medical doctors (Gatero 2011).

As a result of poor ICT skills, medical doctors would deny the opportunity to have access to adequate and reliable information Ololube, Ubogu, and Ossai (2007) affirm that medical doctors' lack of ICT skills is a major obstacle militating against the use. There are three approaches to ICT skills competency standard for medical doctors. These are technological literacy, knowledge deepening and knowledge creation (UNESCO 2011). These approaches are development continuums to promote the use of ICT among medical doctors; and each has its usefulness for the healthcare delivery system, particularly in diagnosis, treatment, professional development of medical doctors, medical practices and hospital administration.

The information and communication technology skills of medical doctors, in Africa, are very low (Idowu *et al*. 2008). The authors further assert that many medical doctors in Africa lack the basic skills to operate computers. As a result, many of them would find it difficult to operate clinical informatics tools.

Appraisal of the literature

The health systems of many African countries are haunted by challenges of accessibility and availability of clinical informatics tools, despite the impressive opportunities that can be gained from the adoption of clinical informatics tools in healthcare. Extant literature indicates that clinical informatics tools development is basically limited to advanced countries of the world, with many healthcare facilities in Africa still lagging behind, in clinical informatics' tools access and use.

Clinical informatics tools are becoming increasingly important aspect of medical practice, and it has contributed significantly to healthcare development at all levels. The adoption of clinical informatics promises a number of significant benefits, which include time management and better healthcare. Serious unintended consequences from the non-implementation of these facilities have emerged, particularly in developing countries. Effective healthcare is fundamental to the global agenda of reducing poverty and a major way of promoting human development. Based on this, access to accurate medical information, in various health care facilities, is very necessary for medical doctors to take effective medical decision. Despite the rapid adoption of clinical informatics in developed countries, the effect of adoption of clinical informatics is very poor. The low rate of adoption of clinical informatics is widening the digital divide between developed and developing countries.

There is an urgent need for careful and nuanced methods to develop and establish the use of clinical informatics in poor countries. The application of clinical informatics is not feasible in developing countries where there is a shortage of medical doctors, in both rural and urban areas. Integrating clinical informatics in the healthcare sector of a country would promote universal and effective healthcare coverage and strengthen the already weakened healthcare systems, especially in rural areas. In order for developing countries, particularly African countries, to be economically viable, politically vibrant and socially secure, there is a need for the effective adoption and utilisation of clinical informatics resources in their healthcare facilities.

The implication of this is that medical doctors in Africa are lagging behind in the use of clinical informatics. There is a need for more studies that would establish the relevance, and usefulness of clinical informatics to medical doctors in the continent. Lack of research may be the reason why different governments in the continent have decided not to invest so much in clinical informatics development in healthcare.

Poor access to clinical informatics resources can result in medical errors, lessen the quality of care, and endanger healthcare development on the continent. Incorrect medical diagnoses, on the part of medical doctors, may have serious legal and financial implications on healthcare facilities. Lack of clinical informatics also has serious implications on the fight against preventable diseases and premature deaths, in developing countries. The poor adoption of clinical informatics, in developing countries, can be traced to poor ICT readiness. ICT readiness can be grouped into basic readiness, ICT readiness, government readiness and clinical informatics.

Even among developed countries, some countries lay greater emphasis on clinical informatics than others. For example, Denmark has a very high level of clinical informatics in her health facilities compared to other Scandinavian countries(European Commission 2017) . The prevalence of the digital divide, in many African countries, is a serious threat to the effective use of clinical informatics in healthcare delivery. Reasons for this may be the unavailability of clinical informatics policies and poor budgetary allocation to health. Any implementation of clinical informatics must also be sensitive to the needs of healthcare users. Effective healthcare depends on the accessibility and availability of clinical informatics tools because clinical informatics tools are the backbone of the services that prevent, diagnose and treat diseases and aliments

The literature review indicates a divide in the use of healthcare facilities, particularly between urban and rural healthcare facilities and developed and under-developed countries. Gaps also exist within healthcare facilities (between departments) and healthcare facilities within the same geo-political zone, particularly in Africa. The adoption of clinical informatics can help to bridge this gap. Through the adoption of clinical informatics, challenges such as distance would no longer be a barrier to delivering quality healthcare. The availability of clinical informatics can contribute significantly to the socio-economic development of rural dwellers because the people will have access to effective healthcare delivery.

Conclusion

For effective adoption of clinical informatics tools usage in Africa countries, there is a need for governments to make funds available for healthcare sectors and relevant training on the usage should be put into consideration. This becomes necessary when the clinical informatics availability and usage in developed and developing countries are compared. Based on the reviewed literature, the study recommends the need for developing countries, particularly in Africa, to organise themselves nationally and regionally, in order to benefit more from the developed world in terms of knowledge transfer, capacity building in healthcare and infrastructure development; as related to ICT and effective healthcare delivery.

Also, medical doctors need to improve their ICT skills, in order for them to be able to harness the potential benefits of using clinical informatics tools. The literature review revealed that there is poor availability of clinical informatics tools as a result of which various hospital managements need to partner with relevant stakeholders like government, corporate bodies and ministries or departments of health, multinational organisations, international health organisations such as WHO, and non-governmental organisations (NGO) for incorporation of clinical informatics tools to their healthcare system. This may be through donation of clinical informatics resources.

In addition, adequate budgetary allocation should be earmarked for acquiring relevant clinical informatics tools. In acquiring relevant clinical informatics tools, public private partnership should be encouraged, since the government alone cannot face the burden of effective healthcare delivery.

The study is limited to four types of clinical informatics tools which are electronic medical record, diagnosis image archiving, computerized decision support system and computerized physician order entry. The decision to use four types of the clinical informatics tools was based on the fact that the socio-economic conditions of most countries in Africa do not favourably support the access to, and use of most clinical informatics facilities; particularly the newer, more complicated and expensive systems.

The contributions of this work can be considered from the point of view of literature, practice, and policy. The review adds to literature by contributing to the conceptualisation of clinical informatics and clinical informatics tools, as aspects of social informatics. The review has also provided an insight into the importance and relevance of clinical informatics tools to modern day healthcare delivery. In addition, the study contributes to debates and discussions on clinical informatics and social informatics. This paper should would add more value when read together with recent studies on the theme by the authors.

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