12th Health Informatics in Africa Conference (HELINA 2019)
Peer-reviewed and selected under the responsibility of the Scientific Programme Committee

Networking and Securing Botswana's Public Health Care System (BPHS) to enable a secure digitalized patient-centered environment.

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Background and Purpose: The aim of the research was to investigate and develop an e-health mobile application with associated algorithms for use in managing patient information collection. The research explored the current role of Information Technologies (ICTs) in the Botswana Public Healthcare System (BPHS). Specifically, it dealt with elucidating, discussing and understanding the current status of BPHS and ICTs role in BPHS in relation to the utilisation of Electronic Health Records (EHRs). The author explored the current BPHS ways of gathering and processing patient information, categorization of the current BPHS and users' satisfaction levels with it and ascertained people's behaviours towards employment and utilisation of ICTs in health.
Methods: Triangulation of quantitative and qualitative methods was followed, with questionnaires, interviews and observation techniques employed to draw conclusions.
Results: There was strong evidence that many users showed dissatisfaction with BPHS, which is mostly paper oriented and manual, and indicated an embracement of mobile applications in health.
Conclusions: The study concluded that the current BPHS is mostly paper based and the satisfaction levels of users negate such systems in this modern era of utilisation of ICTs. In conclusion, the author designed and developed a working prototype for BPHS.

Keywords: e-health, Electronic Health Records, Mobile health Apps

1   Introduction

Many countries around the world have come up with different measures to manage patients' records through introductions and implementations of electronic patient health record systems, which have come to be known with various names such as Electronic Medical Records (EMRs), Electronic Patient Records (EPRs), Computer-based Patient Records (CPRs) amongst the so many names [1] [2] [3]. Thus, these systems have become successful in being able to deliver benefits to the health sector hence the development of an e-health application with associated algorithms for use in managing patient information collection in this research. There is clear evidence that patient records management in the Botswana's public healthcare system (BPHS) is no longer fit for purpose, despite government efforts to diversify it to embrace ICT [4] [5] [6], hence the undertaking of this research. The research explored the current role of ICT in the Botswana Public Health System (BPHS). Specifically, it dealt with elucidating, discussing and understanding the current status of BPHS and ICTs role in BPHS in relation to the utilisation of Electronic Health Records (EHRs), which has become a key component of health administration in various countries. Also explored in perspective, is how other countries have embraced use of EHRs and the associated consequences.

2   Aim and Objectives

The aim of this research was to investigate and develop an e-health mobile application with associated algorithms for use in managing patient information collection. The objectives were:

- To analyse how patient information is gathered and processed on the current Botswana Public Healthcare System (BPHS) with emphasis on primary health care.
- To establish if the categorization of BPHS is paper and or electronic based system.
- To establish the satisfaction of users of the current BPHS.
- To ascertain people's behaviour towards employment and utilisation of ICTs (mobile applications) in health.
- To design and implement an e-health based system with relevant algorithms to process e-medical cards and utilisation of mobile communication.

3   Research Questions

The main research question was "What is the current role of ICT in the Botswana Public Health System (BPHS)?" And the sub-research questions were:

- How is patient information managed at BPHS?
- What is the makeup of the BPHS?
- Are users satisfied with the current system?
- Are users ready for a mobile health application?
- What functionalities and security mechanisms are best suited for an e-health mobile application?

4   Literature Review

4.1   Botswana Situation

Government funded health care services provided free or at subsidized costs to the general population are essential provisions of any civilized nation, and consequently so is the patient records management. There is clear evidence that patient records management in the BPHS is no longer fit for purpose as it has been plagued by many bureaucratic setbacks which could be advanced through usage of ICTs. ICTs are a wide field including "all various media employed in communicating information"[7], and this research focused on use of computer, mobile applications and network hardware in managing patient records known as e-health [1] [2] [3]. Botswana has partnered with various international institutions in the course of finding ways of utilizing ICTs in the health sector which is currently paper based [4] [6] [8] [9]. Researchers and developers alike, have embraced the importance of ICTs in the health sector [10] [11]. Botswana's adoption of use of ICTs in the health sector through its partner institutions have been constrained to use of mobile phones in communicating with patients diagnosed with long term illnesses such as AIDS, Diabetes, Cancer, TB and for appointments making [5] [12] [13] [14] [15] [16], neglecting the cornerstone of health care which includes patient registration, diagnosis and treatment which has remained paper based or manual. This has led to challenges in the patient record gathering, archiving, monitoring and maintenance of patient records [4] [6] [12] in BPHS primary health posts.

Contributing further to the BPHS are the socio-geographic elements which indirectly affects the healthcare system. Many of the dwellers of Botswana are rural occupants, poor or lack training on handling of medical documents or record management [12] [9] [17] [18]. In many circumstances, many rely on firewood, paraffin or gas devices for energy in their homes and lack of proper handling of such could lead to fires which could destroy their entire properties inclusive of medical documents thus leaving them with no concrete medical history for future reference. The general security and integrity of paper based records held by individuals and Health centres leaves these records vulnerable to loss and destruction [19] compounded by lack of records management and archiving skills by individuals [20] [19]. Moreover, escalating the issue is the inefficient and ineffective manual records management system run by the Ministry of Health facilities characterized with lack or limited use of ICTs and lack of relevant ICT skilled personnel [19] [20] [21]. The current "3-way process" has proven to be not efficient for BPHS, and it is summated as follows:

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STEP 1: Patient registration: Patients visiting BPHS facilities are registered with their details captured including proof of identity, and are stored in a hardcopy notebook of the health facility and also on the patient card with the whole process involves only paper and pen.

STEP 2: Patient diagnosing and treatment: Succeeding registration is patient diagnosing and treatment which is done by a health attendant (nurse, doctor or specialist). Many patients do not bring their past illness history cards but only the new card given during registration, with the health attendant having to rely on the oral feedback from the patient whenever they pose the questions to know about their current status and past history. The process culminates with the health attendant prescribing relevant medication or treatment for the ailments and or making judgments to hospitalize or discharge the patient. This process also involves only pen and paper thus is also still manual oriented.

STEP 3: Dispensary: This is the last stage of the BPHS process involving a patient collecting their treatments or medications from the health attendant at the dispensary who relies on the writings on the patient card to give out either treatment or medication, and check to indicate the medication or treatment has been dispensed. There is no record to indicate what medication was given out and to whom. This process also involves manual form of paper and pen utilisation.

With this BPHS process, there is therefore, the potential for misunderstanding, misdiagnosis and mistreatment of patients, all of which affects the efficacy and efficiency of the service as substantiated by Kalogriopoulos et al [2] and the Botswana-Upenn partnership study [9]. Thus, there is a clear practical problem to be addressed in the collection and retentions of patient records in the BPHS, calling for introductions and implementations of electronic patient health record systems for better quality [22].

4.2   Existing relevant knowledge around the world and Sub-Saharan Africa

Many countries around the world have come up with different measures to manage patients' records through introductions and implementations of electronic patient health record systems, which have proved to be a positive outcome in many instances. Aminpour et al [1], Gray [23] and Stone [24] have indicated the importance of these healthcare systems in their studies. These systems have come to be known synonymously with varying names such as Electronic Medical Records (EMRs), Electronic Patient Records (EPRs) Computer-based Patient Records (CPRs), Personal Health Record (PHRs), Electronic Health Records (EHRs) or Computerized Medical Records (CMRs). Some countries who have implemented e-medical record systems include but not limited to USA, United Kingdom, Canada, Australia, New Zealand, Denmark, China and India, both which have made great strides in the electronic documentation of patients [23]. Having countries investing in information technology in health sector indicates how relevant and important this modern trend of utilisation of mobile and computer technology is, and how countries around the world are in need of such technologies to be employed in their health sectors [2]. In Sub-Saharan Africa, some countries have not been slow to take up and adopt EMRs as they have diversified their healthcare systems despite still facing various challenges. Highlighted here are the cases of South Africa, Kenya and Mozambique and the challenges faced by them and others.

South Africa: The South African government has embraced the use of ICTs in its health care as they are capable of bridging the digital divide between rural and urban areas [24] [25] [26]. South Africa is a vast country, and implementation of ICT health systems has been applauded as a great move though it has also come up with challenges due to the vastness of the country [27]. The country introduced the National Health Act (2003) in which it has taken strides to facilitate and co-ordinate the establishment, implementation and maintenance of information systems [28] [29] with the aim of achieving an integrated and enhanced National Health Information System in both the public and private health sector. Due to the vastness of the country, the systems are being run through District Health Management Information System (DHMIS) while efforts are being made to integrate all systems into an amalgamated national system [28]. A concern on the under utilisation of health systems due to paper persistence by some quarters [28] [30] has led to running of parallel systems with some reasons of under utilisation being lack of services, infrastructure and expertise [24].

Kenya: In Kenya, EMRs have been possible firstly due to the collaboration of Moi University School of Medicine (Kenya) and Indiana University School of Medicine (USA) in which an EMR Mosoriot Medical Record System (MMRS) was developed and later renamed to Academic Model for the Prevention and Treatment of HIV/AIDS AMRS [31] [32] [33]. The system provided the health attendants with functions of patient registration and transcribes visit data. Currently more work is still being done in

Kenya to fully engage the public health care to utilisation of ICT services in patient medical records, and just like many of the African countries, it has also engaged mobile phone usage in the various health elements such as TB, malaria [34] [35] [36]. In addition, in other parts of Kenya, similar systems have also been developed with the aim of replacing paper usage in favour of ICT as seen from Western Kenya through the utilisation of PDA/GPS-based system [37] [38].

Mozambique: In Mozambique, an HIV care system was developed with intentions of monitoring patients of HIV/AIDS. The system is known as Open Medical Record System (OpenMRS), and it provides all the necessary related technical assistance to the Ministry of Health of that country. The system is database oriented and it has only been limited to the use by patients of HIV/AIDS [39]. Many factors have been noted as the barrier to further rollout of the system to other areas of the country and inclusion of many ailments to it, and this has been advanced as lack of finances and better infrastructure amongst the reasons, similar to many challenges from other countries [40] [41].

4.3 Challenges

- Lack of ICT infrastructure and resources [27] [31] [42] [43] [44]: poor ICT infrastructure in developing African nations slows development and utilisation of electronic medical records.
- Poor Infrastructure: many African countries have poor infrastructure (roads, rail, networks and power) which contributes negatively in the set up of such systems [42] [46] [47].
- Finance: Many of the African governments and dwellers in developing countries are rural dwellers with limited and or no financial means to sustain the use of ICT technologies [27] [44] [46].
- Lack of integration of health systems [27]: many districts medical centres often have own systems to address certain problems, with many systems developed with response to certain pandemics like AIDS or malaria pandemic leaving the health systems as standalone [46].

5 Methodology

5.1 Methods

The study was carried out in the selected public health post, clinics and hospitals of Botswana (Scottish Livingstone Hospital, Broadhurst 1, 2 and 3 Clinics and Tlokweng Clinic), with the intention of understanding the current role of ICT in the Botswana Public Health System (BPHS). The author triangulated quantitative and qualitative methods, thus following a mixed methodology approach along the pragmatism paradigm lines. For primary data gathering, the triangulation of the quantitative and qualitative research methods was used, with the intentions of breath and depth understanding and corroboration of the problem domain [48] [49] [50] [51] [52], and the techniques of questionnaires, interviews and observation were employed. All the works undertaken for this research complied with the Open University policies and procedures, with research permits sought and given by Ministry of Health and on the concerned health facilities. Ethical research procedures were followed.

5.2 Population and Sample Size

The population has been drawn from an array of participants in Gaborone, Molepolole and Tlokweng and the related public health sectors of those areas (Scottish Livingstone Hospital, Broadhurst 1, 2 and 3 Clinics and Tlokweng Clinic). Babbie et al [53] explain that the population constitutes a large pool in which the sampling elements (group of elements with common sentiments) are drawn from and the findings from them generalized to give out the research findings. The author sampled a size of 200 participants with a confidence interval of ±4 and interval of 95%. 100 questionnaires were distributed in the Gaborone area, with the remaining 100 evenly split between Molepolole and Tlokweng areas. Ten people were interviewed from the health facilities of concern. The author also observed the proceedings at the selected health facilities. Interviews were done only for selected individuals, and the author approached a substantial number of people for interviews in the selected health facilities and their departments to ensure backup in instances where others didn't show up. Quantitative data was analysed through Statistical Package for the Social Sciences and qualitative was done through narrative analysis.

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6   Results Findings And Analysis

The results were drawn from the field work using the methodologies, tools, procedures and participants alluded to and explained in the previously. The raw data collected comprised of literature notes, observation notes, interview notes and questionnaire questions. For the purpose of achieving the aim and the objectives of the study, a total of 200 questionnaires were distributed to the target population with the intention of getting at least 150 at confidence interval of ±4. The researcher provided a variety of ways for participants to return responses, and occasionally followed up on them to ensure a high response rate. Refer to table 1 for summarized feedback, 6.1 and 6.2 indicates summarised demographic and general findings.

Place of Questionnaire	Sent	Target (Threshold)	Received	Percentage (%)
Gaborone	100	68	96	96
Molepolole	50	41	48	96
Tlokweng	50	41	50	100
Total	200	150	194	97

Table 1. Questionnaire Summary

6.1   Demographic findings

Age Variable: Participants of the research were of diverse age backgrounds. Participants with age ranking between (a) 18-25years comprised of the majority of the respondents with 47.9%, followed by the (b) 26-33 age bracket at 25.8% and the (c) 34-41 age bracket with 19.6%. The age groups of (d) 42-49 and (e) 50 and above accounted for 5.7% and 1% responses respectively. Thus, if closely analysed, the age groups of (a), (b) and (c) if expanded and merged together represent 93.3% of the whole sample of the participants, suggesting that majority of the respondents are young to middle aged, with 6.7% showing adults respondents (participants), thus younger people are more likely to participate in questionnaires compared to adults, a view supported by Moore and Tarnai [54]. This aspect of age may have an influence in the understanding of the current role of ICT in the BPHS and how it may be enacted.

Gender Variable: Although the researcher did not put in place cognisant efforts to guarantee equivalent gender distribution of the questionnaire, it is noteworthy to analyse the gender distribution for the study. From 194 responses received, 26.8% represented male respondents with 73.2% indicating female respondents, a significant contrast between the two genders. Many females took part in the study, and this could be attributed to their willingness to actively engage in studies compared to males [54] [56].

Level of Education Variable: This demographic aspect was divided into 5 categories of (a) BGCSE and below representing lower levels of education, (b) Certificate representing tertiary at entry level, (c) Diploma indicating tertiary intermediate level (d) Degree and (e) Postgraduate showing advanced and more advanced levels. From the responses gathered and analysed, it indicates that 44.3% are degree holders, 38.1% diploma holders, with 16.5% indicating certificate holders, BGCSE and below and postgraduate accounting for 0.5%. Many of the respondents have formal education up to a certain level which could be critical in the deployment and utilisation of health ICT systems and or applications and sustains findings that educated people are more likely to participate in surveys [55] [56].

ICT Literacy Level variable: The ICT literacy level is another demographic aspect taken into consideration to understand from the participants their ICT skills. This was measured in three ways being the (a) Basic, (b) Intermediate and (c) Advanced. From the participants responses, it shows that majority of them at 69.6% are of intermediate level when it comes to ICT literacy level with 21.1% showing that they have basic ICT literacy level. Only 9.3% have shown that they are of advanced level. This shows that many participants have some form of ICT literacy level, thus this could play an important role in utilisation of health ICT systems and for basic operations of them.

Profession Area (Health Facility or Not) Variable: It was also important for the author to gather and analyse data related to the profession area of the participant, in which the researcher sought to understand their profession and where it is based. The responses for this variable indicated that 67.0% of the

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participants were not from the health area and those from the health area accounted for 33.0%. From the 33.0%, 51.4% of them were nurses, followed by 25.7% of Nurse Assistants and 22.9% being doctors. Therefore, this translates to affirming that the data gathered embraces all the users of health information systems, especially the general users who are patients to hospitals and indirect users of the systems.

6.2   General Knowledge Variable findings

The general knowledge variable constituted of the following questions.
1. *How is patient information gathered and recorded?*
2. *How are the patient's medical records kept?*
3. *Does your health facility have Internet Connection?*
4. *Your health facility is categorized as what?*
5. *If its paper based, is the patient medical history readily available?*
6. *Rate your satisfaction with your current system?*
7. *If your system is paper based how would you rate the priority for an electronic system.*
8. *The author intends to develop an e-health record based system. What system do you envision?*
9. *Do you have any views on the adoption of an all electronic system.*

Through these questions, the author explored the current BPHS ways of gathering and processing patient information, categorization of the current BPHS and users' satisfaction levels with it and ascertained people's behaviours towards employment and utilisation of ICTs in health. The primary data unearthed concluded the following key issues in relation to BPHS, its users and ICT usage in health. A summary is presented below:

BPHS is Paper Based: Data gathered indicates that 97.9% of the respondents' states that data is gathered and recorded through the means of paper, and 96.4% sustained that the patient records are kept on paper and 97.9% indicated that the BPHS system is paper driven. Therefore all the factors to gauge BPHS indicate that the system is paper oriented. These findings sustain Bussmann et al [15] findings that the Botswana public healthcare system is primarily paper based with minimal ICT electronic/technology driven systems.

BPHS Users not satisfied: Users are not satisfied with the current BPHS. The overall assessment showed that 65.5% participants were unsatisfied, followed by 17.0% who were very unsatisfied, 11.9% who are neither satisfied nor satisfied, 4.1% who are satisfied and 1.5% of those very satisfied. A combination of the very unsatisfied and unsatisfied categories takes the total numbers of generally unsatisfied users to 82.5%, generally satisfied users to 5.6% with the intermediate response rate remaining at 11.9%. This shows a huge disproportion between the satisfactory and unsatisfactory responses and corroborates same findings by other researchers [15] [17] [57].

People are eager to embrace the use of ICTs in health administration: Respondents indicated that they are eager to embrace the use of ICTs in the health administration. Participants overwhelmingly agree that there is need to have an electronic system with a priority of 80.3% and a convincing 84.0% of the participants responded that they want a mobile application. The mobile market in Botswana is growing faster than the Personal Computers (PC) market with an average growth of more than 150% compared to the 20% of PCs, and the government initiatives to promote internet usage play a vital role [36] [79]. Thus, more Batswana own mobile phones with the coverage from statistics indicating 90% coverage, thus mobile phones could play an important role in Botswana and its telemedicine sector [58] [59] [60].

7   Recommendations

- Government should consider investing in high quality health ICT systems and use of mobile devices.
- The government should consider networking all health centres in the country and furnish them with internet connection and mobile devices such as Tablet PCs for doctors and nurses for use in health.
- More security mechanisms and ways needs to be enforced in the Botswana networks.
- There should be provision of trainings to health professionals in relation to use of ICTs.

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8 Conclusions

Patient movement is uncontrolled as they move from one health facility to another, and needed in place is a robust system to connect the gaps caused by patient migration. With the current status of BPHS which is paper oriented and plagued with bureaucracies, this can't be achieved. The displeasure of the users of BPHS, called for a system which is in line with the modern world. The research concludes that the problem of BPHS is far from unsolvable and this research achieved its mandate of understanding the current BPHS setup, satisfaction levels of users of the current BPHS, people's behaviors towards ICTs in health, similar systems from other countries and finally developing an e-health system for the environment of Botswana. The research itself was not without challenges and there remain issues to be solved technically and operationally to enhance on the current delivery.

Acknowledgment

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