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Editorial to JHIA Vol. 11 (2024) Issue 1

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The Journal of Health Informatics in Africa is the official journal of the Pan African Health Informatics Association (HELINA) and publishes the proceedings of the HELINA conferences, as well as open-call issues. This issue is an open-call issue comprising of seven double blind peer reviewed papers submitted directly to the journal. Papers written in French are also published by the journal, and this issue includes one French paper. The year 2023 celebrates the 10th year since the first publication of a JHIA issue and as we celebrate this milestone we are continuously working on improving the quality of the journal.

This issue includes the following papers:

- The paper by Osembe, Adebesin, and Smuts utilise thematic analysis to examine themes around the opportunities for digital innovation in healthcare.
- Author Nyarko recommends strategies to promote artificial intelligence adoption in healthcare decision-making among Ghanaian tertiary students.
- In the paper by Mohsam an analysis of nurses' lived experience with digital health technologies in practice is shared.
- Key competencies for different levels of study and design considerations for a Health Informatics course are identified by authors Bhebe, De La Harpe, Kaura, and Kabaso.
- Author Awami evaluates users' acceptance of a computer-based health information system at Benghazi diabetes centre.
- The paper by Abotsi, Agbemafleb, and Ayimeyc highlights positive outcomes and challenges associated with electronic health records systems at a Ghanaian hospital.
- The French paper by authors Randimbison, Rainibarijaona, Rajaonarison, and Rabenja highlights the impacts of a low-cost software for automated interpretation of fetal heart rate developed for the use in remote areas in low-income countries such as Madagascar.

I would like to extend a very special thank you to the editorial team, authors, and peer-reviewers that made this issue possible.

Nicky Mostert
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Journal of Health Informatics in Africa

Evaluation of users' acceptance of a computer-based HIS at Benghazi diabetes centre

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Background and Purpose: This study investigated whether an electronic medical record implemented at a medical centre was successful and shed the light on some of the factors that may have contributed to such outcome. Important indicators of the system's success include its acceptance by the users, meaningful use, and likelihood of sustainability. The users' acceptance is a reflection of their satisfaction with the amount of effort required, the amount of benefits realized, and the kind of experience they've developed using the system.
Methods: based on user acceptance literature, a questionnaire was designed and administered to clinicians at the medical centre. 18 clinicians participated in this qualitative, descriptive, cross-sectional study to evaluate users' acceptance of the system.
Results: expressing general impression, 56% of the participants think that the system is easy to use and 61% judge the system as useful for supporting their work tasks. Regarding their use experience, third of the participants object that the system's performance was timely and more than 80% agree that the system facilitates data documentation and medication order.
Conclusions: despite the system's suboptimal performance, it is accepted by the users and it is well integrated into their routine work. The few participants who evaluate the system negatively may belong to 'late adopters' group who will eventually adopt. Users' self-efficacy, the mandatory policy of the centre and the leadership of the centre management are some of the factors that may have contributed to such outcome. Issues of system performance and some of the participants' requirements ought to be addressed to insure the system's sustainability.

Keywords: *user acceptance, electronic medical record, HIS implementation challenges.*

1 Introduction

The ultimate goal of HIS implementation projects is to deliver a successful system. System success has been presented as a dynamic multidimensional concept that has different meaning to different parties and evolves over time [1]. Successful systems are effective systems that are adopted and used meaningfully by their intended users. Thus, avoidance of system underutilization and emphasizing the long term use of the system are measures of system success [2, 3]. Kishore and Mclean [4] have suggested two dimensions for success of adoption of IT innovations, diffusion and infusion. They considered diffusion as a measure of the breadth of the adoption which points to the number of potential adapters that have adopted the innovation. And Infusion as a measure of the depth of the adoption which indicates the magnitude of the innovation functionalities that are in use and how well the system is integrated into the routine work of the users. Effective use of HIS has been the concern of governments such as the US, and has initiated programs of financial incentives to promote the adoption of EHR. Healthcare providers are entitled to incentives on the condition of fulfilling the requirements of 'Meaningful Use' of these systems [5].

User acceptance and adoption are important indicators of system success. User adoption is a process composed of several stages, through which users start with the initial awareness and knowledge of the innovation. During this process, users pass through stages of forming an attitude, to taking a decision, to starting to use the innovation, to finally confirm or reverse the decision of adoption if users were dissatisfied [6]. Actually, many studies have considered system success as surrogate to users' satisfaction [7]. User satisfaction is a subjective measure that refers to user self-reported feelings and attitudes of their experience

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using the system. Thus user satisfaction can be measured via scales that estimate users' feelings and intention towards the system. Various constructs can be evaluated for this purpose including: a system's perceived usefulness, perceived ease of use, and performance. It is posited that state-of-the-art information systems can be a poor solution if users appraise it so. This clearly points to the fact that HIS implementation is not merely a technical role out but rather a social process of adaptation and experimentation as well where the stakeholders of the system are at the centre [1, 8].

User acceptance has been explained and elaborated in many theories and frameworks and it reflects user's satisfaction. IS acceptance is an attitude of users towards an IS and it is based on the user's affective and cognitive evaluation of the interaction process with the system. At pre-implementation, users engage in a cognitive process, basically to develop beliefs about the system usefulness and ease of use to reach a decision about whether to adopt the system. This decision is also affected by other factors such as subjective norm and image, which constitute a form of social influence on the individual's decision of adoption [3]. Compliance has been suggested as one determinant of perceived usefulness, which represents the social influence exerted upon individuals during the adoption process. Compliance indicates a situation in which an individual perform certain behaviour in order to attain an award or avoid punishment.

Venkatesh and Bala [3] posit the determinants of ease of use which include computer efficacy, computer anxiety, and computer playfulness. They argue that these determinants form general beliefs about computers and their use, and not necessarily associated with the target system. Consequently, these determinants are responsible for individuals' initial judgment about the IT innovation. Furthermore, the effects of these determinants attenuate after users' gain of hands-on experience with the new system.

Some studies postulate that user acceptance also includes understanding whether the system fits the requirements of the users and the tasks supported. User satisfaction has been defined as the degree to which the system has met the users' expectations and reflects on their interaction with the system – from the user point of view. Thus, it is important to evaluate user satisfaction as a mean for understanding users' experience with the system. Acceptance and satisfaction address the quality of interaction between the system and the users [7]. Moreover, several factors have been identified for user satisfaction including: user involvement in IS development, perceived usefulness, user experience, organizational support, and user attitude towards the IS. Users form attitudes based on their experience with IS, level of competency, and amount of use.

The Delone and McLean model present user satisfaction as one dimension of success along with other dimensions such as system quality, information quality, service quality, system use, and net benefits [7]. Additionally, the model elaborates on the relationship among these dimensions and establishes the interdependency between user satisfaction and other dimensions in the model. One study indicates that system quality is the best determinant of user satisfaction [9]. System quality can be evaluated by assessing a number of indicators such as: response time and the design of its user interface (sequence of tasks on the system).

Task technology fit model assess system success by understanding users' evaluation of the level of fit between task requirements and support provided by the system [7]. The model views information systems as a means to accomplish goal-oriented tasks, and elaborates on the fit between the system, the user, and the task. Likewise, the task-technology fit model can identify whether the system assists or hampers the user. Disconfirmation is another concept mentioned with relation to information system evaluation and is concerned with assessing the gap between the users' expectation and perceived performance of the system. There can be three levels associated with this concept: confirmation (no gap), negative disconfirmation (performance<expectation), and positive disconfirmation (performance>expectation) [7]. Moreover, the users' expectations are determined by their experience which may lead to high or low satisfaction levels. Furthermore, one refinement of this model differentiated between expectations and desires and argued that expectations are based on the rational evaluation of the possibilities and the desires are just what the user expect in the ideal situation.[7]

User expectations are defined as a set of beliefs that targeted users hold of an information system associated with the eventual performance of the IS and their performance using the system [10]. Accordingly, users can have realistic or unrealistic expectations. It is contended that users with unrealistic expectations are more likely to be dissatisfied and may discontinue using the system. Consequently, to set the users' expectations at realistic levels, it is recommended to expose them to game-based training and encourage their participation in the system development process.

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Nine factors have been identified that affect user satisfaction (in order of significance): user involvement, perceived usefulness, user experience, organizational support, user attitude toward IS, perceived attitude of top management toward the project, user expectations, user skills, and ease of use. Hence, systems acceptance is dependent on users' perception that the system they use and the information provided are relevant and useful to their job performance. [10]

Another paper points out to the importance of considering the temporal dimension of the user adoption process and explains the effects of persuasion, training and direct-use experience on users' attitude and adoption and usage decisions [6]. Persuasion of users is undertaken by enthusiastic initiators (champions) who are considered to be part of the social influence [11]. Moreover, they theorize that adoption and use of information systems are ultimately dependent on users' attitude and belief toward the system. Additionally, explain that persuasion and training are responsible for setting users' own unique understanding and expectations of the innovation, and this understanding evolves and can change with increased direct-use experience with the IT innovation. Direct-use experience is a post-adoption phase at which users would have examined the system characteristics. Rogers [12] had defined innovation characteristics to include: relative advantage, compatibility, complexity, trialability, and observability.

One important criterion of IS success is user acceptance, which is a surrogate of user satisfaction. Results from studies in the field of HIS implementation indicate that users are satisfied with the system if it is perceived as useful. Perceived usefulness has many determinants including perceived ease of use, subjective norm, image, and result demonstrability [3]. Perceived ease of use is defined as the degree to which a person believes that using an IT system will be free of effort. Subjective norms point to the degree of perception about the effect of the opinion of important people in the individual's social network on his/her intention and behaviour toward the IT system. Result demonstrability refers to the degree of a person's perception of the results of using the system with regard to being tangible, observable, and communicable.

Perceived ease of use determinants include computer self-efficacy, perception of external controls, computer anxiety and objective usability [3]. Computer self-efficacy is defined as the self assessment by individuals of their own ability to perform job tasks using computers. Computer anxiety points to the degree of apprehension that an individual feels about the prospect of having to use computers. External controls refer to an individual's perception of existing organizational and technical resources at their disposal that could support their use of the computer. Furthermore, Venkatesh and Bala contend that as users start using the system (post implementation) the developed experience becomes a moderating factor for many of the aforementioned determinants of the main constructs of the user adoption process. They mention that experience affects determinants such as subjective norms and computer anxiety. Experience lessens the effect of subjective norm as users start forming their own opinion about the system, and this effect is particularly salient in a voluntary context. It has been suggested that voluntariness negatively affects the users' intention to adopt [11]. Experience also mitigates the effects of computer anxiety and increases the levels of computer efficacy.

This study attempts identifying whether the implemented system at Benghazi diabetes centre is a success and shed the light on some factors that may have contributed to such outcome. Benghazi diabetes centre provides healthcare services to diabetes patients and covers patients from the whole eastern region of Libya. It is essential for the centre to maintain an information system for managing records of their patients and to have a memory of their medical history. New patients are required to register at the reception, and then they are issued a card with a unique identification number that they need to keep for future visits. The centre belongs to the Libyan government and provides its services free of charge, including the medication.

The innovation used is proprietary software developed by a local IT company and enables medical documentation and supports physicians' orders for lab tests and diagnostic imaging. It manages the medication prescription process and coordinates the process of transfer of patients between physicians inside the centre. It presents menu lists of diagnostic and therapeutic terms which were developed locally and used for data entry. After authentication of the user, the visit screen pops up and consists of relevant components such as patient history, review of systems tab, assistance for writing prescription including medication name list and corresponding dose and route information. It also enables the generation of a number of predefined medical reports, such obesity report and number of medication dispensed report. It also has lab and pharmacy components used by the laboratory and the pharmacy at the centre to execute physicians' orders. The self initiated project to implement the system is championed by the centre director, who is a doctor himself. All funds necessary to set up the LAN and finance the system were donated by

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local businessmen who were approached by the centre director. The system was developed specifically for the centre and based on requirements identified by the management.

Important indicators of the system's success include its acceptance by the users, meaningful use, and likelihood of sustainability. Thus, the main question posed was: Is the system implemented at Benghazi diabetes centre accepted by the users? This entailed the following sub-questions:

- How many of the clinicians use the system and how frequent?
- Was the system easy to use? (general impression and elements)
- Was the system useful? (general impression and elements)
- What experience did the users have while using the system?
- What facilitating factors had contributed to the outcome?

The users' acceptance is a reflection of their satisfaction with the level of effort required to use the system, the amount of benefit that has been realized, and the kind of experience they've developed using the system. Furthermore, meaningful use reflects the system's level of integration into the users' routine work and breadth of functionality use.

2 Methods

This cross-sectional descriptive qualitative study aimed at understanding physicians' acceptance and experience with an electronic medical record implemented at Benghazi diabetes centre. As well as identify some of the sociotechnical factors that have played a role in this outcome.

The study took place during the summer of 2022. A questionnaire was distributed by the medical staff director to elicit information from physicians at the centre. A total of 18 physicians participated and filled out the questionnaire. The questionnaire consists of 41 items, both open and close questions. 33 of these items asked direct questions about the system, the rest covered demographic information, computer and IT literacy, and one open question for general comments.

The questionnaire was designed to elicit data about the following aspects: system use, ease of use, usefulness, user's experience and facilitating factors. In addition to demographic questions and open-ended questions to further explore participants' thoughts and opinions.

Ease of use was probed through questions about participants' general impression and specific elements that factor into this aspect of the system. These specific elements are evaluated through inferring users' interactions with the aspect's elements of the system. Specific element questions included, for instance, system intuitiveness and clear presentation of data. Similarly, usefulness was probed through questions about the participants' general impression and the usefulness aspect of specific elements, most of which are about the level of fit between the provided system support and work task requirements. Participants were asked to reflect on their experience with the system's support for routine tasks such as: communication, coordination, documentation, information search, and order management.

User Experience reflects users' trust and comfort with the system and assumes noting observable events that occurred while using the system, such as failures and work delays. User experience was probed by eliciting users' testimony on incidents or events that have happened regarding:

- Trusting data presented by the system and whether the participants have come across a situation where they questioned the data integrity and have no reason to doubt information presented.
- System failure and recovery: system failure rate and whether users can manage a plan of action once it happens,
- Security: they trust that the system keeps the patients' data securely.

Facilitating factors include questions probing existing and contextual factors that could have contributed to the system acceptance outcome, these included users' characteristics, training provided, technical support available, and participation in the system development process.

3 Results

The following tables represent data extracted from the returned questionnaires as absolute numbers and calculated percentages. Demographically, most of the participants' are female, aged between 31 1nd 40, and have on average 9 years of work experience as clinicians (Table 1)

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Table 1: Participants demographics

Characteristic	Number	Percentage
Age group		
25-30	1	6%
31-40	15	83%
41-50	2	11%
Gender		
Female	16	89%
Male	2	11%
Years of experience		
1-5	3	16%
6-10	13	72%
11-15	1	6%
16-20	1	6%

Facilitating factors existed in the context that could have influenced the system evaluation outcome include participants' level of computer competency, adequacy of the training provided, and belief in health information technology are tabulated (Table 2). Third of the participants agreed that the training course was adequate and another 22% agreed cautiously. 44% of the participants doubted the adequacy of the training course. Only 22% of the participants participated in the system development process.

Table 2: Facilitating factors

Characteristic	Number	Percentage (%)
Prior computer training		
Yes	4	22
No	14	78
Computing skills		
beginner	5	28
intermediate	13	72
advanced	0	0
Attended training course		
Yes	10	56
No	7	39
No answer	1	5
Training course was adequate		
strongly agree	2	11
agree	4	22
somewhat agree	4	22
do not agree	4	22
do not know	4	22
Technical support available		
strongly agree	3	17
agree	5	28
somewhat agree	8	44
do not agree	2	11
do not know	0	0
Participated in the development process		
yes	5	28
no	11	61
no answer	2	11
Believe in role of HIS		
yes	13	72
no	2	11
no answer	3	17
Prior knowledge of EHR		
yes	3	17
no	13	72
no answer	2	11

Data presenting participants' impression and feeling about general aspects of the system such as ease of use, being a burden, usefulness, contribution to patients' satisfaction and health care quality are

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demonstrated in (Table 3). 39% of the participants do not agree that the system was burden. Third of the participants agreed that the system contributed to patients satisfaction and two third agree that the system contributed to positively to the quality of healthcare provided.

Table 3: Clinicians impression n(%)

Item	TA	A	SWA	DA	DK	NA
The system is easy to use	7(39)	3(17)	7(39)	1(5)	0	
I trust patient information provided by the system	4(22)	4(22)	6(33)	3(17)	0	1(5)
The system is an extra burden	3(17)	4(22)	4(22)	7(39)	0	
The system was useful in supporting work tasks	2(11)	9(50)	5(28)	2(11)	0	
The system has contributed to patients satisfaction	2(11)	4(22)	6(33)	1(5)	5(28)	
The system is highly effective in supporting the daily tasks	4(22)	5(28)	4(22)	4(22)	0	1(5)
The system contributes to raising the level of health care quality in the centre and the city	4(22)	8(44)	2(11)	1(5)	2(11)	1(5)
note: Totally agree (TA), Agree (A), Somewhat agree(SWA), Do not agree (DA), Do not know (DK), No answer provided (NA)						

Table 4 demonstrates the participants' experience with using the system with respect to speed of response, intuitiveness, and supporting specific aspects of their routine work such as documentation and order management.

Table 4: Clinician experience with the system

Item	TA	A	SWA	DA	DK	NA
The system performance is timely	0	1(5)	11(61)	6(33)	0	0
Sequence of tasks on the system is logical and fits workflow	5(28)	2(11)	7(39)	3(17)	0	1(5)
The system helps with communicating with colleagues	4(22)	4(22)	1(5)	9(50)	0	0
The system supports keeping patient data safe	5(28)	8(44)	4(22)	1(5)	0	0
The system is important for coordinating tasks with colleagues	4(22)	7(39)	2(11)	5(28)	0	0
The system facilitates patient data documentation	5(28)	10(56)	2(11)	1(5)	0	0
The system finds patients medical history easily	6(33)	5(28)	6(33)	1(5)	0	0
The system facilitates order of lab tests	3(17)	7(39)	3(17)	2(11)	3(17)	0
The system facilitates following up lab test results	3(17)	10(56)	2(11)	1(5)	2(11)	0
The system facilitates ordering medication prescription	5(28)	11(61)	1(5)	1(5)	0	0
The system enables access to all information needed to make a decision about patient cases	3(17)	9(50)	3(17)	2(11)	1(5)	0
The system helps in preparing educational material for patients	1(5)	3(17)	2(11)	11(61)	1(5)	0
note: Totally agree (TA), Agree (A), Somewhat agree(SWA), Do not agree (DA), Do not know (DK), No answer provided (NA)						

Summary of the participants' responses to the open questions of the questionnaire:

- The most important features/advantages of the system to the participants are:

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The most acknowledged feature/advantage of the system is its basic ability as a tool for the efficient data saving and timely retrieval of patient data and medical history. The second most appreciated advantage by the physicians is the system's support for the management of healthcare process through better organization of patient visits and fair allocation of daily work load among working physicians. Other features appreciated by the physicians included the system support to their daily medical tasks such as following up lab test and medication management. As well as enabling better quality healthcare, as quoted by one participant "[it] ensures the dispensing of medication to all liable Libyan citizens".

- The challenges that faced the participants while using the system:

The most frequently challenge of the system reported by physicians is its slow performance and frequent failures which caused numerous delays on busy working days.

- Features or functionalities the participants think were unnecessary:

None, all are necessary

- Functionalities that need to be added to the system

Mainly requests for executing some tasks quicker such as retrieval of patient's past medication list, suggestions for improving some user interface items such as text boxes, expanding the medication and disease menu lists, altering some information sequence display, improving some task sequence and produce more data summary reports.

4 Discussion

Most of the participants had no computer training and self assessed their computer competency as intermediate. 56% of the participants attended the training course and only third of them either agree or strongly agree that it was adequate. The system has no user manual or documentation, which suggests that many physicians have used other means to learn about the system, which could be a support from their peers and self learning about the system. Furthermore, or used the technical support available, although only less than half of the participants agree that such support was sufficiently available. This suggests that this group of physicians can be assessed as having a high level of computer efficacy as individual characteristics.

All users indicated using the system on daily basis with all patient cases. Essentially, this may be attributed to the centre's policy that mandates the system use.

A considerable percentage of the participants believes in health information systems in general. However, only three participants stated they have prior knowledge about electronic health record systems.

In terms of the system ease of use, the majority have a positive general impression about this aspect of the system (more than half of the participants agree that the system was easy to use as well as 39% agreed with some reservation). In terms of usefulness, most of the participants have positive general impression with this aspect as around two-third of the participants think that the system is generally useful in supporting their work tasks, in addition to another 28% agreed with some reservations.

Participants' experience of using the system to perform work tasks differed from one element to another, the system slow speed was their worst experience. The system intuitiveness rate good as 39% of the participants agree or totally agree that the sequence of tasks on the system was logical and matched their workflow and another 39% agreed with reservation, which suggests that the system use was perceived as requiring minimal effort.

In terms of supporting their daily tasks: 50% of the participants do not find the system supportive to their communication with colleagues, although 44% of their participants have perceived the system as a useful communication channel. However, in terms of using the systems for coordinating tasks between colleagues, 61% agree or strongly agree that the system is important with this respect. Worth noting is that the system does not provide any form of electronic communication such as email or messaging services, but, provides a distinct function for managing patient transfer between doctors.

Most of the participants agree that the system is an effective means for documenting patient data. 75% trust the system with keeping patients' data safe. With regard to system ability to search and find patient medical history easily 61% agree or strongly agree in addition to another 33% agree with some reservations. With respect to the system function as order management tool for lab tests and medications, 56% agree that the system improved test ordering task, 73% agree that following up of test results is easier, and 89% agree that the system improved ordering medications from the pharmacy. Only 17% of the participants seem to

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be not using the function of lab test orders. However, none of the participants stated non-usage/unawareness of the medication ordering function of the system.

With regard to system ability to provide all information needed to make a decision about patient cases, the majority agrees that the system provides such access.

Participants demonstrated some division on answering a question regarding the system help in preparing educational material for patients, as 61% do not agree that such help is provided, correspondingly, 22% agree that such help is provided although no direct function for preparing and generating educational material is available on the system. This could signify that some physicians may have improvised a derived use of the system to support certain tasks, such producing educational material for patients. The same postulation may be valid to understand the perception of some participants of the system as communication channel that mentioned earlier. This further suggests that the system is well integrated into the users' workflow.

5 Conclusion

The results indicate that the system is accepted by the physicians at Benghazi diabetes centre. Physicians perceive the system as useful, and it is well integrated into their routine work. The users mostly appreciated the system support for core tasks such as secure documentation of patients' data, patient history search, coordination with colleagues, and order management. As well as, appreciate the system's transparency and role in creating a fair work environment where everyone has an equal share of the workload. Furthermore, they've noted a high degree of fitness between support provided by the system and many of their task requirements.

Although the physicians have rated the system ease of use favourably, they faced some technical challenges related to the systems' performance that need to be addressed quickly to maintain the users' acceptance. Participants reported experiencing system slow response, work delays, and difficulties handling large numbers of patients. There are also a few improvement requests by the users that ought to be considered and implemented to establish users' ownership of the system that further cement the infusion of the system.

The system context has also provided a number of factors that have contributed to the successful implementation of the system which include: the fact that the system use in the centre is mandatory, the standardized type of healthcare provided by the centre to a specific group of familiar patients (frequent diabetes patients with past medical records), and the full support of the centre management to the system. The users' self-efficacy might have had an effect as well, as despite the non-existence of a system manual and low attendance rate to the training course, the users were able to manage using the system effectively.

References

[1] Berg, M., Implementing information systems in health care organizations: myths and challenges. International Journal of Medical Informatics, 2001(64): p. 143-156.

[2] Davis, F.D., R.P. Bagozzi, and P.R. Warshaw, User Acceptance of Computer Technology: a Comparison of Two Theoretical Models Management Science, 1989. **35**(8): p. 982-1003.

[3] Venkatesh, V. and H. Bala, Technology Acceptance Model 3 and a Research Agenda on Interventions. Decision Sciences, 2008. **39**(2): p. 273-315.

[4] Kishore, R. and E.R. McLean. Diffusion and Infusion: Two Dimensions of "Success of Adoption" of IS Innovations. 1998 [cited 2007 9/4/2007]; Available from: http://is.lse.ac.uk/Support/AMCIS/AMCIS1998/pdffiles/papers/t17_09.pdf.

[5] Braunstein, M.L., Practitioner's Guide to Health Informatics. 2015: Springer.

[6] Xia, W. and G. Lee, The influence of persuasion, training, and experience on user perceptions and acceptance of IT innovation. 2000.

[7] Despont-Gros, C., H. Mueller, and C. Lovis, Evaluating user interactions with clinical information systems: A model based on human-computer interaction models. Journal of Biomedical Informatics, 2005. **38**(3): p. 244-255.

[8] van den Wijngaart, L.S., et al., Barriers and facilitators when implementing web-based disease monitoring and management as a substitution for regular outpatient care in pediatric asthma: qualitative survey study. Journal of medical Internet research, 2018. **20**(10): p. e9245.

 J Health Inform Afr. 2024;11(1):1-9. DOI: 10.12856/JHIA-2024-v11-i1-357

[9] Hadji, B., et al., 14 Years longitudinal evaluation of clinical information systems acceptance: The HEGP case. International Journal of Medical Informatics, 2016. **86**: p. 20-29.
[10] Mahmood, M.A., et al., Variables affecting information technology end-user satisfaction: a meta-analysis of the empirical literature. International Journal of Human-Computer Studies, 2000. **52**(4): p. 751-771.
[11] Li, J., et al., Health care provider adoption of eHealth: systematic literature review. Interactive journal of medical research, 2013. **2**(1): p. e2468.
[12] Rogers, E.M., Diffusion of Innovations. 5th ed. 2003, New York: Free Press.

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Positive Outcomes and Challenges of Electronic Health Record Systems: A Case of A Ghanaian Hospital

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Background and Purpose: Medical professionals keep a patient's medical record current using the Electronic Health Record System (EHRS), an electronic version of the document. It includes the crucial clinical and administrative information needed to manage the patient's treatment, such as demographics, issue notes, progress notes, prescriptions, vital signs, previous medical records, vaccination records, laboratory results, and radiological reports.
Methods: The grounded theory methodology was used to review relevant literature and lay the groundwork for this investigation. Additionally, the information was gathered via a well-structured questionnaire distributed to medical professionals. The main objective of the study was made clear to the participants. The researchers distributed questionnaires to the individuals who provided healthcare using EHRS at their places of employment. Any queries the participants had regarding the questionnaire were allowed to be answered.
Results: The main driving force behind this study was finding out what function AlphaChem Hospital's EHRS performs in delivering high-quality care. The study's key findings were that the EHRS helps the hospital by enhancing the accuracy of patient records, enabling the simultaneous care of multiple patients, streamlining appointment scheduling, and decreasing the time spent providing care while maintaining high user satisfaction. Frustrating factors include issues with lack of technical training, lack of technical support, and unstable internet connectivity.
Conclusions: Most healthcare providers at AlphaChem Hospital were satisfied with the system and chose the electronic health record system over the paper-based one. However, there were some challenges with EHRS utilization. The report suggests that facility administrators properly orient all staff members on using the system. A facility that wants to gain a competitive edge must adopt, contribute to, and use an electronic health record system to manage health services.

Keywords: Electronic Health Record System (EHRS), electronic medical record, healthcare, surgical, obstetrics

1 Introduction

The 2019 World Health Statistics (WHS) examines life expectancy, causes of death, and health-related SDGs. The significant findings and supporting data for tracking health-related Sustainable Development Goals (SDGs) are needed for a practical discussion of health policy and program planning implications [1]. The availability of accurate data can help achieve some of the goals of many hospitals. In an EHRS, doctors and nurses and to a larger extent, patients are able to keep track of medical history digitally. Such records could include the patient's demographics, progress notes, problems, prescriptions, vital signs, past medical history, vaccines, laboratory results, and radiology reports, among other administrative and clinical information essential to providing the care the patient requires [3].

An electronic medical record (EMR) is an electronic record of a person in a doctor's office or clinic that is typically in one setting and provider-centric [4]. The phrase "electronic health record system" (EHRS) involves the continuous electronic record of a person that virtually connects to data in multiple electronic medical records (EMRs) and electronic patient records (EMRs and EPRs), is shared among healthcare providers, and is patient-centric [5]. The World Health Organization (WHO) has included healthcare quality as its priority for the overwhelming majority of the medical system, including those in nations that are developing [6].

Healthcare institutions are adopting systems for complete electronic health records swiftly. Such platforms may improve the provision of healthcare services and serve as data repositories for a range of

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information gleaned through outpatient assessments [7]. Using EHRS, healthcare practitioners can improve the level of care they deliver while taking further steps to handle persistent sickness, avert it, and identify specific individuals.

Electronic Medical Records (EMR) systems are being more widely used in both industrialized and underdeveloped countries [8]. Advanced regions prioritize integrating electronic medical records into patient care, whereas impoverished countries face considerable barriers to implementation [9]. Electronic health records allow for the safe sharing of patient information within a group of authorized individuals, even when that care is provided by different medical facilities [10]. Patient billing, investigation order and receipt, prescription, clinical data recording, and in some cases decision assistance software are all characteristics and benefits of an EHRS [11]. Also, EHRS is used by healthcare professionals to enhance better results via their care management initiatives in addition to charting for patients [12].

The biggest issues with the EHRS that were identified were a lack of patient uptake, poor training, a lack of technical assistance, an increase in workload, and data sharing [13], intermittent network connections, subpar network architecture, limited staff understanding, an absence of dedication from top management, and a lack of interoperability and interaction with other systems including lab, x-ray, and digital tomography scan [14].

2 Materials and Methods

The grounded theory approach was deployed in reviewing the literature to form the basis of this study. This approach entails a thorough and organized search of published research to find pertinent publications which are evaluated critically and synthesized to present an overview of the available data on a specific issue. The grounded theory method of doing a literature review is to achieve a thorough and theoretical grasp of a field or topic [15].

The essential terms connected with Electronic Health Records Systems (EHRS), such as Electronic Medical Records (EMR), Computerized Patient Records (CPR), Health Information Systems (HIS), Digital Patients Records (EPR), personal medical records (PHR), were used to create the review's focus.

These critical phrases were identified in health-related academic databases such as MEDLINE, PsycINFO, EMBASE, Education Research Complete (health education - full text), Scopus, Sage Journals (Technology and Medicine - full text), and Emerald.

2.1 Issues and Evidence

The adoption and usage of EHRS and their effects on healthcare delivery were recognized as the main problems when dealing with EHRS in the literature review. The use of EHRS is influenced by attitudes toward them, perceptions of their utility and usability, social influence, computer self-efficacy, possible risks to medical autonomy, and privacy concerns [16] [17]. Despite the clear benefits, many hospitals and clinics must switch to electronic health records (EHRs) for patient management.

One of the essential factors discovered to influence healthcare professionals' decision to adopt an EHR system is their level of computer literacy [16]. EHRS has impacted healthcare practitioners. Physicians, nurses, and other healthcare professionals all reported similar experiences following the deployment of EHRs, with a change in how they perceived their work but no change in their intrinsic motivation [18]. Clinical evaluation practices have improved since the installation of EHRS, and medication errors have decreased [19].

Additionally, electronic health records systems (EHRS) enable healthcare institutions to save and retrieve data and particular patient information for use by healthcare professionals; these EHRS enhance productivity, raise customer happiness, and protect patient data privacy [20]. Nurses have voiced concerns about the EHR's dependability, despite many doctors applauding its potential to prevent medical errors by offering more information quickly for accessibility. Interoperability appeared to be a problem due to the absence of thorough system integration [21].

2.2 Study Site

The study was conducted at the AlphaChem Hospital in Accra, Ghana. The hospital features a number of departments, including an emergency room, an obstetrics and gynaecology ward, an outpatient department

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(OPD), and a male and female medical and surgical department. Additionally, it serves as a main referral hospital for all other clinics in the Metropolis and offers high-quality care to the nearby villages.

Full-time medical officers at AlphaChem Hospital include surgeons, dermatologists, obstetricians and gynaecologists, as well as a part-time eye specialist who works on Tuesdays and Thursdays. The clinic also offers ultrasound, computerized tomography (CT), maternal and child health welfare, and tuberculosis treatment as additional services.

2.3 Study Sample

The electronic health records system and its contribution to high-quality healthcare at the AlphaChem Hospital were identified through the descriptive cross-sectional design of the study, which used quantitative tools. The hospital has several departments; the Out-Patient Department (OPD), Emergency unit, Male and Female medical and surgical departments, Obstetrics and Gynaecology ward etc.

All healthcare professionals at the AlphaChem Hospital were included in the population of this study. There were hundred (100) healthcare professionals in the AlphaChem Hospital at the time of gathering data for this study. However, only eighty (80) of them responded to the questionnaire and interviews.

A medical professional from each ward with at least two years' worth of experience delivers high-quality care using an electronic health record system. The two years were intentionally picked under the presumption that anyone working on a system would have been aware of its purpose and significance within that time frame. Participants who satisfied the above requirements were chosen for participation in this study. A healthcare worker who had less than two years of experience working was disqualified, as were non-healthcare providers like the security team, protocol officers, cleaners, and health safety officers. These individuals do not have any kind of direct access to the EHRS that the medical centre was deploying in its operations. This serves as the exclusion criteria for the selection of the participants for the study.

2.4 Data Collection Instrument

In accordance with Andersen's model (12), a questionnaire was utilized. This questionnaire included questions regarding demographic characteristics, enabling factors (such as employment status, occupation, income level, health insurance status, and how patients use health facilities), and need factors (such as self-rated health, co-morbidities, and severity of illness). A well-structured questionnaire that was given to healthcare professionals with at least two years of experience was used to gather the data. Data collected from participants with experience reduces information bias, boosting the information's reliability.

The main objective of the study was made clear to the participants. The participants who rendered healthcare using EHRS were given questionnaires at their places of employment. The participants were also given a chance to ask questions regarding the questionnaire if they had any questions, and the method of data collecting in no way revealed the identities of each respondent. A thoughtfully constructed questionnaire was utilized to gather data from knowledgeable participants to reduce information bias and improve the reliability of the findings. The method's ability to forecast whether the same results will be obtained after repeated application was tested for reliability.

2.5 Ethical considerations

Prior to the enhanced data acquisition processes, the goal of the study was declared to the administrator of the AlphaChem Hospital and his approval was sought to meet the ethical requirements of the study. Also, all participants who matched the inclusion criteria were asked to give their consent, either verbally or in writing with no coercion. The participants' involvement in the research was entirely optional, and they were free to withdraw at any time or refuse to answer any or all of the study's questions.

2.6 Data Analysis

The data gathered from the survey was statistically analyzed using SPSS 16. Additionally, the data was processed using the descriptive statistics, percent and frequencies mean analysis. Classified data were described using frequency and percentages, whereas continuous variables were summarized using mean and standard deviation.

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3 Results

3.1 Socio-Demographic Information of Participants

A total of 80(100.0%) participants participated in this study. The socio-demographic information covers the sex, age, working experience, profession and the clinical ward of each participant. Majority of the participants were females 49(61.3%) between 25-30 years 31(38.8%) and a few of 1(1.3%) were below more than 40 years.

A greater part of the participants, 54(67.5%), represented 2-3 years of working experience, while a minority of only 2(2.5%) represented above five years of working experience. It is indicated that most health workers took nurse 26(32.5%) as their profession, whilst 14 (17.5%) represented the medical ward (Table 1).

Table 1: Frequencies and Percentages of Demographic Variables.

Information participants		***Frequencies (n=80)***	***Percentage(%)***
Sex			
	Male	31	38.8
	Female	49	61.3
Age			
	Below 25 years	18	22.5
	25-30years	31	38.8
	31-35 years	24	30.0
	36-40 years	6	7.5
	More than 40 years	1	1.3
Working Experience			
2-3 years		54	67.5
4-5 years		24	30.0
Above 5 years		2	2.5
What Is Your Profession?			
Nurse		26	32.5
Medical doctor		17	21.3
Midwife		14	17.5
Pharmacist		12	15.0
Laboratory technician		11	13.8
Ward			
Surgical		11	13.8
Medical		14	17.5
Pediatric		9	11.3
Out Patients Department		6	7.5
A&E		8	10.0
Obstetrics/Gynecology		9	11.3
Pharmacy		12	15.0
Laboratory		11	13.8

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3.2 The Attitude of Healthcare Providers Towards EHRS

According to the various responses, the majority of the 80 (100%) respondents—31 (22%)—agreed that they had enough knowledge to operate an EHRS, while just three (3.8%) strongly disagreed. Thirty-six (36) respondents representing 45.0%, strongly agreed that EHRS are necessary for healthcare delivery, whereas only 1 (1.3%%) strongly opposed it. Thirty-seven (37) people, or 46.3%, strongly agreed or disputed that EHRS improves the duties of other healthcare team members. Only one person, or 1.3%, strongly disagreed. While the majority, 29(36.3%), agreed that using the EHRS in the facility is required, a small number, 9(11.3%), disagreed that it should be used because it is required. Additionally, a more significant percentage—32(40.0%)—agreed that using EHRS is a waste of time, whereas just a tiny percentage—6(7.5%)—strongly disagreed.

Again, the majority, 25(31.3%), disputed that they feel pressured to use EHRS to deliver high-quality care to patients, while the minority, 4 (5.0%), strongly agreed with this notion. While 18(22.5%) of the respondents were dissatisfied with the system's precision, the majority of respondents, 62(77.5%), were pleased with it. Nineteen (19) respondents (28.3%) do not receive technical training or support while utilizing the platform, while 61 respondents (76.3%) do (Table 2).

Table 2: Frequencies and Percentages of Attitude of healthcare providers towards EHRS

The attitude of healthcare providers towards electronic health record systems.	***Strongly Disagree***	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***
I have sufficient knowledge of the use of EHRS.	n=3(3.8%)	n=7(8.8%)	n=19(23.8%)	n=31(38.8%)	n=20(25.0%)
EHRS play an important role in healthcare delivery.	n=1(1.3%)	n=0(0.0%)	n=8(10.0%)	n=35(43.8%)	n=36(45.0%)
EHRS enhances the work of other healthcare team members.	n=1(1.3%)	n=3(3.8%)	n=5(6.3%)	n=34(42.5%)	n=37(46.3%)
I use EHRS because it is compulsory in the facility.	n=0(0.0%)	n=9(11.3%)	n=23(28.7%)	n=29(36.3%)	n=19(23.8%)
Using EHRS is not time-consuming.	n=6(7.5%)	n=11(13.8%)	n=14(17.5%)	n=32(40.0%)	n=17(21.3%)
I do feel pressured when using EHRS to provide quality care to patients.	n=14(17.5%)	n=25(31.3%)	n=18(22.5%)	n=19(23.8%)	n=4(5.0%)
				Yes	***No***
Are you satisfied with the accuracy of the system?				n=62(77.5%)	n=18(22.5%)
Do you get enough technical training and support when using the system?				n=61(76.3%)	n=19(28.3%)

3.3 Benefits of EHRS Contributing to Quality Healthcare

The multiple responses from the table indicate that out of the eighty 80(100.0%) respondents, the majority of 33(41.3%) representing agreed that improvement in quality care could be through EHRS, whilst a minority of 1(1.3%) representing improving quality care could be through EHRS was strongly disagreed. In contrast to the study, 34(42.5%) agreed that EHRS is worth the time and effort required, whilst 1(1.3%) respondent strongly disagreed. Most, which is 40(50.0%), strongly agreed that EHRS reduces paper-based medical charts and filling charts whilst a few 2(2.5%) strongly disagreed. A few 4(5.0%) disagreed to the notion that EHRS is easy, faster and accessible, whilst majority 31(38.8%) agreed and strongly agreed to the notion that EHRS is easy, faster and accessible.

Also, a more significant number, 37(46.3%), strongly agreed that patient information was safer and more secure on EHRS, whereas 1(1.3%) disagreed with this idea. Again, the majority, 42(52.5%) representing, agreed that they do find the reports generated by EHRS valuable and easy to understand, whilst the minority 1(1.3%) representing strongly disagreed with the idea. The majority of the respondents, 65(81.3%), could request laboratory tests and other medical services on the EHRS, whilst 15 (18.8%) could not request

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laboratory tests and other medical services on the EHRS. Most respondents, 72(90.0%), approved that EHRS monitor the progress of in and outpatients in the facility, whilst 8(10.0%) do not approve (Table 3).

Table 3: Frequencies and Percentage of Benefits of EHRS Contributing to Quality Healthcare

Benefits of electronic health record system contributing to quality healthcare.	***Strongly Disagree***	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***
I can increase or improve quality care through EHRS.	n=1(1.3%)	n=6(7.5%)	n=17(21.3%)	n=33(41.3%)	n=23(28.7%)
EHRS is worth the time and effort required to use.	n=1(1.3%)	n=7(8.8%)	n=18(22.5%)	n=34(42.5%)	n=20(25.0%)
EHRS reduces paper-based medical charts and filling charts.	n=2(2.5%)	n=0(0.0%)	n=6(7.5%)	n=32(40.0%)	n=40(50.0%)
EHRS is easy and fast accessible.	n=0(0.0%)	n=4(5.0%)	n=14(17.5%)	n=31(38.8%)	n=31(38.8%)
Confidentiality of patient's information on EHRS.	n=2(2.5%)	n=1(1.3%)	n=6(7.5%)	n=34(42.5%)	n=37(46.3%)
Do you find the reports generated by EHRS useful and easy to understand?	n=1(1.3%)	n=2(2.5%)	n=18(22.5%)	n=42(52.5%)	n=17(21.3%)
Benefits of electronic health record system contributing to quality healthcare.				**Yes**	***No***
Can you request laboratory tests, x-ray and other medical services on the EHRS?				n=65(81.3%)	n=15(18.8%)
Does EHRS help monitor the progress of in and out patients in the facility?				n=72(90.0%)	n=8(10.0%)

3.4 Challenges Faced During the Usage of EHRS

Majority representing 36(45.0%) were sure to state that EHRS is cumbersome to use whilst minority representing 2(2.5%) said that EHRS is not cumbersome to use. As many as 24(30.0%) disagreed that time to enter data affect EHR system contribution and its time wasting whilst 7(8.8%) respondent strongly agreed. Majority of 31(38.8%) low internet speed when using the system is good whilst 5(6.3%) disagreed to it. A few 3(3.8%) strongly disagreed to the notion that poor internet connection slows productivity whilst majority 35(43.8%) agreed that poor internet connection slows productivity. Also, a greater number 35(43.8%) agreed that lack of computers affects EHRS contribution to quality healthcare whereas 3(3.8%) strongly disagreed to the idea.

Again, majority 29(36.3%) representing respondents who wrote patient's information were easily accessed by healthcare providers and kept confidential for quality care whilst minority 9(11.3%) representing those who wrote EHRS helps to monitor the progress and benefits all patients. Majority of the respondents 61(76.3%) said lack of sufficient training and computer skills of the healthcare providers result in low work productivity whilst 19(23.8%) said no to it.

Majority of the respondents 62(77.5%) approved that patient's information input meets their expectation whilst 18(22.5%) do not approve. The contribution and usage of EHR system improved the management of records in the hospital by Patient's information/ data were easily accessed by healthcare providers and kept confidential for quality care 29(36.3%) accounted for majority, Reports generated by EHRS is useful and easy to understand, old files retrieved, fast reference to improve productivity 27(33.8%), Reduction of errors, missing files, time wasting and requesting of test results to scheduling of patient appointments 15(18.8%) and less accounted for EHRS helps to monitor the progress and benefits all patients 9(11.3%) (Table 4).

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Table 4: Frequencies and Percentage of challenges faced during the Usage of EHRS

Challenges faced during the usage of electronic health record systems.	***Frequency***	***Percentage (%)***
The EHRS in AlphaChem Hospital is cumbersome to use.		
Strongly disagree	36	45.0
Disagree	21	26.3
Neutral	7	8.8
Agree	14	17.5
Strongly agree	2	2.5
Total	**80**	**100.0**
The time to enter data affects EHR system contribution and is time-wasting.		
Strongly disagree	9	11.3
Disagree	24	30.0
Neutral	20	25.0
Agree	20	25.0
Strongly agree	7	8.8
Total	**80**	**100.0**
Low internet speed affects the use of the system.		
Strongly disagree	7	8.8
Disagree	5	6.3
Neutral	31	38.8
Agree	27	33.8
Strongly agree	10	12.5
Total	**80**	**100.0**
Poor internet connection slows EHRS use.		
Strongly disagree	3	3.8
Disagree	4	5.0
Neutral	15	18.75
Agree	47	58.75
Strongly agree	11	13.7
Total	**80**	**100.0**
Lack of computers/hardware affects EHRS's contribution to quality healthcare.		
Strongly disagree	3	3.8
Disagree	8	10.0
Neutral	11	13.8
Agree	35	43.8
Strongly agree	23	28.7
Total	**80**	**100.0**

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Table 4 Continues: Frequencies and Percentage of challenges faced during the Usage of EHRS

	Frequency	Percentage(%)
Do the patient's information input meet your expectation?		
Yes	62	77.5
No	18	22.5
Total	**80**	**100.0**
Does the lack of sufficient training and computer skills of healthcare providers result in low work productivity?		
Yes	61	76.3
No	19	23.8
Total	**80**	**100.0**
Has the contribution and usage of the EHR system improved the management of records in the hospital*?*		
Patient information/ data are easily accessed by healthcare providers and kept confidential for quality care.	29	36.3
Reduction of errors, missing files, time-wasting and requesting of test results to the scheduling of patient appointments.	15	18.8
Reports generated by EHRS are useful and easy to understand, old files retrieved, and fast reference to improve productivity.	27	33.8
EHRS helps to monitor the progress and benefits all patients.	9	11.3
Total	**80**	**100.0**

Table 5: Identified challenges facing the effective use of EHRS

Challenges facing the effective use of electronic health record systems.	***Frequency***	***Percentage(%)***
I am aware of the challenges facing the use of EHRS in AlphaChem Hospital		
Strongly disagree	0	0
Disagree	0	0
Neutral	0	0
Agree	29	36.25
Strongly agree	51	63.75
Total	**80**	**100.0**
Challenges of the EHRS AlphaChem Hospital		
Lack of Technical Training	38	47.5
Lack of Technical Support	12	15
Unstable Internet Connectivity	21	26.25
Lack of Computers	2	2.5
I Prefer Old Folder System	7	8.75
Total	**80**	**100.0**

3.5 Challenges Faced During the Usage of EHRS

The majority representing 36(45.0%) were sure to state that EHRS is cumbersome to use whilst minority representing 2(2.5%) said that EHRS is not cumbersome to use. As many as 24(30.0%) disagreed that time to enter data affect EHR system contribution and its time wasting whilst 7(8.8%) respondent strongly agreed. Majority of 31(38.8%) low internet speed when using the system is good whilst 5(6.3%) disagreed to it. A few 3(3.8%) strongly disagreed to the notion that poor internet connection slows productivity whilst

majority 35(43.8%) agreed that poor internet connection slows productivity. Also, a greater number 35(43.8%) agreed that lack of computers affects EHRS contribution to quality healthcare whereas 3(3.8%) strongly disagreed to the idea.

Again, majority 29(36.3%) representing respondents who wrote patient's information were easily accessed by healthcare providers and kept confidential for quality care whilst minority 9(11.3%) representing those who wrote EHRS helps to monitor the progress and benefits all patients. Majority of the respondents 61(76.3%) said lack of sufficient training and computer skills of the healthcare providers result in low work productivity whilst 19(23.8%) said no to it.

Majority of the respondents 62(77.5%) approved that patient's information input meets their expectation whilst 18(22.5%) do not approve. The contribution and usage of EHR system improved the management of records in the hospital by Patient's information/ data were easily accessed by healthcare providers and kept confidential for quality care 29(36.3%) accounted for majority, Reports generated by EHRS is useful and easy to understand, old files retrieved, fast reference to improve productivity 27(33.8%), Reduction of errors, missing files, time wasting and requesting of test results to scheduling of patient appointments 15(18.8%) and less accounted for EHRS helps to monitor the progress and benefits all patients 9(11.3%) (Table 4).

4 Discussion

4.1 Nature of Responses

At the AlphaChem Hospital in Accra, Ghana, 80(100%) healthcare providers participated in the data-gathering process by responding to a developed questionnaire. The study found 49 female participants, or 61.3% of the total, compared to 31 male participants, or 38.8%. According to the study's age range, 25 to 30 years old (38.8%) reacted the most, followed by 31 to 35 years old (30.0%), under 25 years old (18.5%), 36 to 40 years old (6.7%), and those above 40 years old (1.3%), in that order.

According to the demographic data, the employment experience of participants ranges from 2-3 years to 4-5 years to more than five (5) years. The majority of healthcare professionals who worked for 2-3 years were 54(67.5%), followed by 24(30.0%) for those who worked for 4-5 years, and the fewest participants (2, 2.5%) who worked for more than five (5) years. The profession that received the most responses was nursing with 26(32.5%), followed by medicine with 17 (21.3%), midwifery with 14(17.5%), pharmacy with 12(15.0%), and laboratory with 11(13.8%). 14(17.5%) of the volunteers were in the medical wards, while 12(15.0%) were in the pharmacy. 11(13.8%) respondents from the surgical ward and 11(13.8%) from the lab participated in the survey.

Pediatric ward respondents comprised 9(11.3%), whereas Obstetrics and Gynecology ward respondents comprised 9(11.3%). 6(7.5%) and 8(10%) responders each came from the Out-Patient Department (OPD) and Accident & Emergency Department, respectively. Most of the nurses in the medical ward are likely in general nursing practice, accounting for the distribution in the ward.

4.1.2 Attitude of Healthcare Providers Toward the Use of EHRS

From this study, healthcare professionals know how to use EHRS. Fifty-one (51) people representing 63.8%, demonstrated varying levels of EHRS understanding. Only 10 (or 12.6%) of those tested had poor EHRS knowledge, whereas 19 (23.6%) had adequate knowledge. Some healthcare professionals are reluctant to adopt new technologies that they need to become familiar with because healthcare providers do not see EHRS favorably (7.87%). It is evident from this study that many participants thought EHRS significantly impacted how well care is delivered in the nation.

EHRS compiles all patient demographic information into one extensive database and leverages it to help develop "new treatment or ingenuity in healthcare delivery, ultimately advancing healthcare aims. According to the study's findings, 32 respondents (40.0%) claimed that using EHRS takes time, while thirty-six (36) respondents representing 45.0%, affirm the EHRS's importance in healthcare delivery, including improving other healthcare providers' efficiencies.

The complicated nature of the program, which necessitates a lot of internet data, knowledgeable trainers, and frequent maintenance/support, caused some other respondents to express conflicting opinions about its viability. According to the administrator of the AlphaChem Hospital, there has been some resistance to the transition of some practitioners and health professionals from manual to digital documentation. At the same time, most healthcare workers know it could take time to alter behaviors and attitudes, if not wholly, to

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meet patients' expectations. The EHRS enables redesigning clinical procedures to create a more effective working method.

4.1.3 *Benefits of EHRS Contributing to Quality Healthcare*

40(50.0%) of the participants used EHRS for other reasons than charting for patients; healthcare providers use data from patient records to improve quality outcomes through their care management programs. According to this study, the quality of care could be improved through EHRS by a majority of 33(41.3%). Further, EHRS help staff avoid mistakes and improve the quality of patient care [22].

As a result of illegibility, high storage costs, and the difficulties of remote file access, the manual system of preserving paper records slows down healthcare services, whereas EHRS increases healthcare efficiency [13]. Healthcare professionals' reluctance to switch from manual (paper-based) to digital reporting has been an issue which sometimes results in inaccurate data [23] [24]. However, this study revealed that the number of paper-based medical records has decreased by EHRS 40(50.0%).

Most research participants—65, or 81.3%—reported using the EHRS to request medical services, including x-rays and lab testing. According to the study's findings, 34 (2.5%) and 37 (46.3%) highly agreed that patient information confidentiality is more reliable and secure on EHRs.

4.1.4 *Challenges Faced During the Usage of EHRS*

The 36(45.0%) that responded that EHRS was cumbersome to use identified lack of suitable training 38(47.5%), lack of technical support 12(15%) whiles using the system as some of the contributing factors. These issues hindered the use and the effectiveness of EHRS at the AlphaChem Hospital. Also, the lack of adequate guidance and relevant computer skills to aid in navigating the system by several healthcare providers resulted in seeing the EHRS as cumbersome.

Another challenge of effective deployment of EHRS at the AlphaChem Hospital includes unstable internet connectivity 21(26.3%). The system (EHRS at the AlphaChem Hospital) relied on internet connectivity to share data among between the users. Thus a reliable 24-hour internet connectivity as a backbone for EHRS is crucial since data availability and sharing need real-time. However, the internet connection was not stable which hindered effective service delivery using the EHRS since a stable internet penetration is one of the critical determinants of the success of EHRS [25].

Behavioral problem 7(8.75%) also hindered the success of AlphaChem Hospital's EHRS, as some healthcare providers preferred to obtain patient data manually rather than input it into the EHRS. Most healthcare personnel know it can take time to modify their behavior and attitude to meet their clients' expectations (18). In addition, AlphaChem Hospital lacked sufficient workstations 2 (2.5%) for optimal EHRS usage. Consequently, the absence of computers affects workflow by increasing the time spent directly providing for patients and contributing to more extended treatment periods of high quality.

Finally, the EHRS systems were left to run independently with minimal supervision. Adequate supervision allows managers to identify and correct mistakes and also ensure that standards are maintained. Problems such as lacking a complaints section or channels for addressing EHRS challenges could be easily identified and corrected without adequate monitoring and supervision.

4.2 Limitations of the Study

Although our study has provided evidence to support the literature on the usage of EHRS, the attitudes of healthcare providers toward EHRS, the advantages of EHRS, and the problems associated with the use of the EHRS by individuals seeking health care and caretakers, we are aware of several limitations.

Some participants of the study may not have told the truth in their answers, and the researchers did not rule this out. The research method was time-consuming, the questionnaires were challenging to fill out, and numerous participants failed to appear on the planned days. Patients and EHRS users who cannot recollect when they first experienced difficulties could have been affected by recall bias; this was minimized by asking participants to recall the first time they engaged with the system.

5 Conclusion

Every healthcare organization that wishes to remain competitive must adopt, support, and use an electronic health record system. Most professionals were satisfied with the system and preferred it to paper records,

although there were occasional challenges with doctors using EHRS. Contemporary healthcare organizations are continually improving the standard of patient care, and Healthcare consumers constantly demand excellent service from their suppliers. The results demonstrated that the AlphaChem Hospital EHR system significantly raised the patient care standard. The implementation of an EHRS, according to the study's findings, has improved the standard of care and decreased patient wait times.

The EHR system's capacity to provide many reports quickly has led to a rise in provider expectations. The study's key conclusions were that the hospital benefited significantly from the EHR system in terms of patient records, concurrent patient care, quality requisitions, streamlined appointment scheduling, lack of discrimination, prevention of waste, reduction in time, adaptability to patient needs, system satisfaction, laboratory test requests, and a wide range of healthcare services.

Although issues with the EHR system still need to be overcome, including buying the necessary hardware infrastructure, end users' restrictions, payment issues, redundancy issues, wait times, internet connectivity, and data/information gaps. Ample financing, management, supervision, training, and support are necessary for the healthcare system to remain viable. This study recommends that facility managers properly train each employee on how to use the system. There is also a need for more computers, qualified IT personnel, and proficient monitoring and administration.

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References

[1] WHO. World health statistics 2019: monitoring health for the SDGs, sustainable development goals [Internet]. 2019. Available from: https://www.who.int/publications/i/item/9789241565707
[2] Deng W, Bao L, Liu J, Xiao C, Liu J, Xue J. Primary exposure to SARS-CoV-2 protects against reinfection in rhesus macaques. Science (80-). 2020;369(6505):818–23.
[3] O'Malley AS, Draper K, Gourevitch R, Cross DA, Scholle SH. Electronic health records and support for primary care teamwork. J Am Med Informatics Assoc. 2015;22(2):426–34.
[4] Strudwick G, McGillis Hall L, Nagle L, Trbovich P. Acute care nurses' perceptions of electronic health record use: A mixed method study. Nurs Open. 2018;5(4):491–500.
[5] Asadi-Lari M, Tamburini M, Gray D. Patients' needs, satisfaction, and health related quality of life: Towards a comprehensive model. Health Qual Life Outcomes. 2004;2:1–15.
[6] Bremond-Gignac D, Lewandowski E, Copin H. Contribution of Electronic Medical Records to the Management of Rare Diseases. Biomed Res Int. 2015;2015.
[7] Holanda AA, Do Carmo E Sá HL, Vieira APGF, Catrib AMF. Use and satisfaction with electronic health record by primary care physicians in a health district in Brazil. J Med Syst. 2012;36(5):3141–9.
[8] Shuaib W, Suarez JM, Romero JD, Pamello CD, Alweis R, Khan AA. Transforming patient care by introducing an electronic medical records initiative in a developing country. Health Informatics J. 2016;22(4):975–83.
[9] Alsohime F, Temsah MH, Al-Eyadhy A, Bashiri FA, Househ M, Jamal A. Satisfaction and perceived usefulness with newly-implemented Electronic Health Records System among pediatricians at a university hospital. Comput Methods Programs Biomed [Internet]. 2019;169:51–7. Available from: https://doi.org/10.1016/j.cmpb.2018.12.026
[10] Jones SS, Heaton PS, Rudin RS, Schneider EC. Unraveling the IT Productivity Paradox — Lessons for Health Care. N Engl J Med. 2012;366(24):2243–5.
[11] Cowie MR, Blomster JI, Curtis LH, Duclaux S, Ford I, Fritz F. Electronic health records to facilitate clinical research. Clin Res Cardiol. 2017;106(1).
[12] Goyal S, Chauhan S, Gupta P. Users' response toward online doctor consultation platforms: SOR approach. Manag Decis. 2022;60(7):1990–2018.

[13] Bisrat A, Minda D, Assamnew B, Abebe B, Abegaz T. Implementation challenges and perception of care providers on Electronic Medical Records at St. Paul's and Ayder Hospitals, Ethiopia. BMC Med Inform Decis Mak [Internet]. 2021;21(1):1–12. Available from: https://doi.org/10.1186/s12911-021-01670-z
[14] Powell KR. Patient-Perceived Facilitators of and Barriers to Electronic Portal Use: A Systematic Review. CIN - Comput Informatics Nurs. 2017;35(11):565–73.
[15] Raglan GB, Margolis B, Paulus RA, Schulkin J. Electronic health record adoption among obstetrician/gynecologists in the United States: Physician practices and satisfaction. J Healthc Qual. 2017;39(3):144–52.
[16] Wolfswinkel JF, Furtmueller E, Wilderom CPM. Using grounded theory as a method for rigorously reviewing literature. Eur J Inf Syst. 2013;22(1):45–55.
[17] Sibiya MN, Akinyemi OR, Oladimeji O. Computer Skills and Electronic Health Records (EHRs) in a State Tertiary Hospital in Southwest Nigeria. 2023;137–47.
[18] Ngusie HS, Kassie SY, Chereka AA, Enyew EB. Healthcare providers' readiness for electronic health record adoption: a cross-sectional study during pre-implementation phase. BMC Health Serv Res [Internet]. 2022;22(1):1–12. Available from: https://doi.org/10.1186/s12913-022-07688-x
[19] Yoo S, Lim K, Jung SY, Lee K, Lee D, Kim S. Examining the adoption and implementation of behavioral electronic health records by healthcare professionals based on the clinical adoption framework. BMC Med Inform Decis Mak [Internet]. 2022;22(1):1–9. Available from: https://doi.org/10.1186/s12911-022-01959-7
[20] Veenstra GL, Rietzschel EF, Molleman E, Heineman E, Pols J, Welker GA. Electronic health record implementation and healthcare workers' work characteristics and autonomous motivation—a before-and-after study. BMC Med Inform Decis Mak [Internet]. 2022;22(1):1–15. Available from: https://doi.org/10.1186/s12911-022-01858-x
[21] Agbese A, Ada F, Ikonne I, Chinyere N. Electronic Health Records (EHRS) Use and Quality Healthcare Delivery by Physicians in Tertiary Hospitals in Federal Capital Territory, Nigeria. Libr Philos Pract. 2021;2021(January):1–12.
[22] Antwi FM. General Surgery and Clinical Medicine. 2023;1(1):1–21.
[23] Upadhyay S, Hu HF. A Qualitative Analysis of the Impact of Electronic Health Records (EHR) on Healthcare Quality and Safety: Clinicians' Lived Experiences. Heal Serv Insights. 2022;15.
[24] Chao WC, Hu H, Ung COL, Cai Y. Benefits and challenges of electronic health record system on stakeholders: A qualitative study of outpatient physicians. J Med Syst. 2013;37(4).
[25] Arndt BG, Beasley JW, Watkinson MD.

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Journal of Health Informatics in Africa

Expert Perspectives on Competencies in Health Informatics for Informatics Students

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Background and Purpose: Informatics practitioners who are knowledgeable in health informatics and understand the need for clinical practitioner workflows contribute towards improved health information systems. The aim of this paper is to discuss insights gained from health informatics experts on their perspectives on competencies that could be taught to informatics students. The researcher explores (i) the competency needs of ICT students and practitioners to develop health ICTs with the involvement of healthcare practitioners, and (ii) how informatics education can be designed to incorporate healthcare domain knowledge in the training of ICT practitioners.
Methods: A questionnaire was administered to health informatics experts. The research sample was purposively selected to include practitioners who have worked in the Health Informatics domain, and have at least a Master's degree. Respondents identified topics and competencies appropriate for teaching undergraduate informatics students.
Results: Thematic analysis identified key competencies for different levels of study and design considerations for a Health Informatics course.
Conclusions: Having Health domain Knowledge may provide opportunities for more roles that IT practitioners can play, especially for those who are not scientifically strong.

Keywords: Health Informatics, Informatics Education, Expert Perspectives.

1 Introduction

Nurses, the largest group of Healthcare Information Systems (HISs) end users, are unable to have an impact on HIS development in the way they would choose [1]. Having informaticians who understand the needs of clinical practitioners based on the workflows in a health environment will result in enhancing the advantages of the use of HIS [2][1]. The advantages of Information and Communications technology (ICT) proven by literature, are: promoting ease of documentation; quick retrieval of required information; prevention of medication errors; monitoring alerts; and increasing the use of Evidence Based Practise[3][4]. Information Technology (IT) practitioners in their praxis as they design, develop, implement, and maintain Health Information Systems (HISs) work through collaborative efforts with domain experts in the various contexts that they work [2]. These collaborative efforts, however, are impeded, because health practitioners have insufficient time to dedicate to HIS development and they lack end user engagement, as users prefer to engage with practitioners that are familiar with the context of practice. Having hybrid informatics and clinical practitioners onsite who understand both the health workflow as well as the information technology development needs, aids in improving and providing safer HISs [1][6]. It is therefore imperative for informatics practitioners to have health knowledge, for them to be hybrid practitioners that understand the context of informatics in the health field [2][7].

The process of digitalising health databases and patient electronic records has enabled convenient, affordable, and timely provision of care in African countries [8]. This has provided a great promise in Africa where much of the population are urban rural and have public health systems that have many constraints in terms of infrastructure and capacity [9][10][11][12]. A diversity of emerging Information and Communications Technologies (ICTs) are being used in healthcare [13], thereby providing a plethora of

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technologies that IT practitioners can implement for different health contexts in both urban and rural settings. This also offers a diversity of roles which IT practitioners can take up within the health field. This they have done in the following ways: (1) In the design and development, implementation, support and maintenance of HITs [14]); (2) By re-using and implementing custom made software within HISs; as well as (3) Working in an entrepreneurial capacity [15]; and (4) Encapsulating legacy electronic medical records into new enterprise-wide Electronic Health Records (EHR) applications [16].

The IT practitioners learn these competencies from their training institutions as part of their courses in their curriculum [17][18]. In order to design, develop and implement ICT Systems for a particular context, IT practitioners work in collaboration with domain experts within that context. This is not unfamiliar to them as, traditionally, IT practitioners in their praxis work collaboratively within their different roles [19]. Challenges with collaboration have been that domain experts consider the time spent on the effort as an 'overhead', and additionally, the participants' authority may be limited [1][20][21]. This has led to many unsuccessful implementations of HITs [22][23][24] as there would be a disconnect between the design of the health ICT system and the 'desired use' of the systems [25][26]. Having ICT practitioners who have Health Informatics competencies aids in reducing the implementation challenges of health ICT systems that are irrelevant [2][27][28].

According to Valenta et al. [31], a competency is,'…an observable ability of a … professional, integrating multiple components such as knowledge, skills, values, and attitudes. Since competencies are observable, they can be measured and assessed to ensure their acquisition. Competencies can be assembled like building blocks to facilitate progressive development.' While there is much literature on the determination of competencies for health practitioners, there is paucity in literature in the determination of competencies for informatics practitioners. Internationally there are two Health Informatics competency frameworks that have researched various contexts to derive competencies for informatics practitioners within the health field, these are the International Medical Informatics Association (IMIA) competencies [32], and the Health Information Technology Competencies (HIT Comp) competencies [32] frameworks.

The IMIA Competency framework, formulated in 2010, was conceptualised by a multidisciplinary team of International Experts who had competencies in both the Health Field and the Informatics field [33]. The Working Group first met in 2008 to conceptualise the methodology for acquiring the competencies and deriving the conceptual framework that guided the inquiry. The final IMIA competency framework is structured into knowledge domains that are offered to two types of roles of professionals at different levels of knowledge. The knowledge domains are classified in the following categories: (1) biomedical and Health Informatics core knowledge and skills; (2) medicine, health and biosciences, health system organisation; (3) informatics/computer science, mathematics, biometry and (4) optional modules in BHMI and from related fields. These knowledge domains were developed for the following roles of users: (1) IT users and (2) Biomedical Health Informatics Specialists. They are designed to be offered at the following levels of skill: (1) Introductory, (2) Intermediate or (3) Specialist. In their review of the IMIA competencies, Mantas and Hasman [2] note that the competencies were still relevant and that informatics practitioners should have Health Informatics knowledge to enable the implementation of relevant and sustainable Health Information Applications.

The HIT Comp framework was also formed from a combination of international perspectives. An international survey was conducted requiring Practitioners who had knowledge in both the Health and Informatics to indicate competencies they felt were necessary for both Health and Informatics Practitioners [32]. The result of the survey was a selection of 250 health IT-impacted competencies throughout the continuum of care. Competencies may be selected according to one of five grades of experience and skills for HIT competence and competencies, these may be Baseline, Basic, Intermediate, Advanced and Expert. Additional criteria include that the IT practitioner may be working in one of six general areas of interactions, which are: administrative; clinical; communication; health data; operational and patient.

Expert perspectives were used in the two competency inquiries to derive the competencies. The perspectives of experts have been used in studies to obtain a greater paradigm of the discipline in question. Experts are better able at synthesising relevant details from large sets of information, and have spent more

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time analysing problems, therefore are better at identifying multidisciplinary knowledge for other domains [34[35]. Thus, for Health Informatics competencies, which are multidisciplinary in nature, exploring expert perspectives forms a valuable component. This paper focuses on gaining insights into health informatics experts' perspectives on competencies that could be taught to informatics students, and it forms part of a larger study. The paper explores the following: 1. The competency needs of African ICT Students and practitioners for developing Health ICTs with the involvement of healthcare practitioners as part of their work activities in practice.; 2. How Informatics education can be designed to incorporate healthcare domain knowledge in the training of ICT practitioners.

2 Materials and methods

This study was conducted using a cross-sectional design data was collected using an unstructured questionnaire which was administered to Health Informatics Experts. Purposive sampling of experts who had diverse experiences across multiple domains of Health Informatics, was conducted. The respondents were recruited by sending an email invitation with a link enabling them access to the questionnaire. Respondents were selected from both informatics and health backgrounds to gain a wide perspective from both disciplines. All experts have experience working in South Africa or similar low- and middle-income country (LMIC) contexts. Thematic analysis was conducted on the results from the responses.

2.1 The Questionnaire

The questionnaire was designed to be completed in approximately 30 minutes and was pre-tested for face validity and readability by two practitioners, with Health Informatics Knowledge at Doctoral Level. The questionnaire was then administered online via Google Forms to the participants. The questionnaire had two sections: (1) Demographics, which required the background and professional experience of the respondents; and (2) Questions on topics and competencies in Health Informatics. The latter provided a contextual setting to providing a landscape on the background of the students as well as the focus of the subject that the students would be taking. The contextual setting was:

> 'If you were asked to design a Health Informatics course in an undergraduate programme to teach it students to develop, implement and evaluate health information systems, health information technologies or health applications for the African context, what topics would you suggest? Please list the five to ten most important topics?'

The respondents were then asked to conduct the following: (1) Please list your suggested topics and add a short description for each; (2) Please indicate the proposed level of study for each of your suggested topics. This was either as a 1st year degree, diploma, 3rd year degree or 4th year degree level of education; (3) Please indicate for each of the suggested topics what students would be expected to do; (4) Please indicated for each of the suggested topics the competencies that students should have; (5) How can IT practitioners already working in the field acquire the necessary healthcare; and (6) Anything you would like to add that may be useful to consider for the African context?

3 Results

3.1 Demographics

Twenty invitations were sent out to Health Informatics experts, and 10 responded. Of the ten respondents, four were female and six were male. For their highest qualification, five of the respondents had a Master's degree and five had Doctorate degrees. One respondent was retired, and some respondents came from organisations from South Africa, Mozambique, UK and Finland.

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3.2 Topics and competencies

The results indicate that 57 sub-competency themes were identified by the respondents and grouped into 18 key competency themes. A wide variety of important areas of competencies was identified and proposed to be offered at different levels of study. Most of the topics had a health focus, providing health domain knowledge to integrate with the IT knowledge that the students would already know. Seven of the topics, however, were suggested for offering across all the levels of study. These are: Introduction to HI; Governance and Policy in HI; Governance and Management of HI; Ethics in HI; The Health Provision Context; Healthcare Knowledge in HI; Health Information Systems Reliability; and Logical Use and Patient Centric Development of Digital Solutions. These seven topics in the degree Programmes would be staggered across 1st year, 3rd year and/or 4th year courses. There were three Health Domain Specific competency topics that were suggested, these were suggested for both the 4-year course and the Diploma course and are: An overview of Health functioning and biosciences, a knowledge of the countries or context Health Systems Structures; Health practitioners workflow practise, and Public Health knowledge. As Public Health knowledge is broad experts suggested the following content: (1) Introduction to Public Health; (2) Patients, Citizens and Community Centred Healthcare and (3) Social Determinants of Health. This knowledge is suggested to be staggered across the 4-year course, with Public Health being offered for the third year and fourth years only. Additionally, Epidemiology is suggested as a competency topic for the 4year course, with it being offered staggered across the third year and fourth year.

3.2.1 First year competencies

In total, 11 key competencies were identified as appropriate for teaching to First Year students. These were broken down into 23 competency topics identified by the health experts as appropriate. A broad overview of the topics needs to be conducted for the students to gain knowledge and some understanding of the fundamentals of the topics.

Table 1: Suggested Topics and Competencies for 1st Year Students

Key Competencies	Sub-Competency Topics
Health Informatics (HI) Fundamentals	• Introduction to HI • History of Information Management of ICT Apps in Healthcare
Healthcare Systems	• Models of Healthcare Systems
Trends in Health Informatics	• Current Trends in HI • Examples of Current and Future ICT in Healthcare
Governance	• Governance and Policy in HI • Governance and Management of HI
Ethics	• Ethics in HI • Privacy, Data Security and Information Quality • Patient Confidentiality
Healthcare Work Practice	• Healthcare Professionals and their Work • Understanding Healthcare Work Context • The Health Provision Context
Data Science	• Data Presentation and Visualisation • Data Integrated Care and Ethical Principles
Health	• Definition of Health • Right to Health
Management of Change	• Management of Change
Health Information Systems	• Healthcare Knowledge in HI • Basics of Healthcare and Usability • Health Information Systems Reliability and Logical Use • Patient Centric Development of Digital Solutions
Public Health	• Back-end Systems
Health Information Systems Practical Experience	• Work Integrated Knowledge

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3.2.2 Third year competencies.

In total, 16 Key Competencies were identified as important for third year students to learn. Within these thirty-nine competency topics were noted by the Health Informatics experts. Students at this stage of the course are expected to have the foundational concepts of the topics indicated for the 1st year and are building on that knowledge so that they are able to have competencies of judgement, analysis and evaluation of health contexts and health information systems.

Table 2: Suggested Topics and Competencies for 3rd Year Students

Key Competencies	Sub-Competency Topics
Ethics	• Ethics in HI • Privacy, data security and information quality
Healthcare Work practice	• The Health Provision Context
Health Information Systems Practical Experience	• Work Integrated Knowledge
Data Science	• Data Science of HI • Data Analysis to improve care provision
Health	• Epidemiology
Health Information Systems	• Healthcare Knowledge in HI • Basics of Healthcare and Usability • Health Information Systems Reliability and Logical Use • Patient Centric Development of Digital Solutions • Digital Information Technology in HI • Logical Usability • Nursing and Nursing Technology
Management of Change	• Management of Change • Management Framework
Telehealth	• Telehealth, Telemedicine, Teleconferencing
Research	• Research • Research Disease and Injury Prevention • Prevention and Responding to Infectious Disease
Design	• User Experience Design • Interactional Design • Participative and Transformative Systems Design and Implementation
Systems Development Life Cycle	• Software Application Development • Back-end Systems • Work and Service Improvement through ICT Systems Development • Systems Theory • Logical Framework and other Frameworks
Multi-professional Project Work	• Multi-professional Project Work
Public Health	• Introduction to Public Health • Patients, Citizens and Community Centred Healthcare • Social Determinants of Health

3.2.3 Fourth year competencies

In total, 15 key competencies and thirty-four competency topics were identified by the Health Informatics experts as appropriate for fourth year students. Students at this level are capping their knowledge attained from their prior years. They are expected to be able to evaluate, make recommendations and develop health systems that are appropriate in diverse contexts. This is evidenced by the Health Informatics experts

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recommending eight competency topics as appropriate for just the fourth-year level study. These were: Impact Assessment of Health Information Technology; Role of Health Professionals in Information Management; Building Blocks of Health; Information Technologies in HI; Digital Health; Usability Testing; Implementation Process; and Implementation Science in Health Services.

Table 3: Suggested Topics and Competencies for 4th Year Students

Key Competencies	Sub-Competency Topics
Healthcare Work practice	• Role of Health Professionals in Information Management • The Health Provision Context
Data Science	• Data Integrated Care and Ethical Principles • Data Science of HI
Health	• Building Blocks of Health • Epidemiology
Health Information Systems	• Healthcare Knowledge in HI • Basics of Healthcare and Usability • Health Information Systems Reliability and Logical Use • Patient Centric Development of Digital Solutions • Digital Information Technology in HI • Logical Usability Information Technologies in HI • Digital Health • Usability Testing
Management of Change	• Management of Change
Telehealth	• Telehealth, Telemedicine, Teleconferencing
Research	• Research
Systems Development Life Cycle	• Software Application Development • Back-end Systems • Work and Service Improvement through ICT Systems Development • Logical Framework and other Frameworks • Implementation Process • Implementation Science in Health Services
Multi-professional Project Work	• Multi-professional Project Work
Public Health	• Introduction to Public Health • Social Determinants of Health
Health Information Systems Practical Experience	• Work Integrated Knowledge

3.2.4 Diploma competencies

Nine key competencies were suggested for the diploma course. Diplomas differ from degree programs in time and focus. They are offered for a shorter time period and their focus is vocational unlike the degree programs which are academic in focus. These key competencies were broken down into seventeen sub-topics for competencies.

Table 4: Suggested Topics and Competencies for Diploma Students

Key Competencies	Sub-Competency Topics
Health Informatics Fundamentals	• Introduction to HI
Trends in Health Informatics	• Evaluating Health Interventions
Governance	• Governance and Policy in HI • Governance and Management of HI
Ethics	• Ethics in HI • Ethics of Health Data
Healthcare Work practice	• The Health Provision Context

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Data Science	• Data Integrated Care and Ethical Principles • Data Science of HI • Healthcare Knowledge in HI
Health Information Systems	• Basics of Healthcare and Usability • Health Information Systems Reliability and Logical Use • Patient Centric Development of Digital Solutions • Digital Information Technology in HI • Logical Usability
Telehealth	• Telehealth, Telemedicine, Teleconferencing
Public Health	• Social Determinants of Health
Health Information Systems Practical Experience	• Work Integrated Knowledge

3.3 Methods of Upskilling

The respondents were further asked to describe their topics and indicate competencies they would expect the Informatics students to acquire once they have learnt the topic. The descriptions and competencies were coded to form descriptions and competencies for key competencies. The respondents were also asked for recommendations on how IT practitioners in practice may be upskilled to gain these competencies. Recommendations are indicated in Table 5 below.

Table 5: Suggested methods of upskilling for IT Practitioners

Methods of Upskilling
• Staggered 3/4 year course • Short Online Course • Summer/Winter schools • Hands-on experiences • Reading • Shared learning experiences with health practitioners

3.4 African Context Perspectives

Additionally, respondent were asked what other characteristics would be important for the African context that they would recommend. They offered the following considerations:

'The international situation is fast-moving and eclectic. Keeping a watching brief on both political national / international situations and priorities; academics must establish development of high level contacts or getting involved in international, governmental and local policy bodies and initiatives relating to informatics deployment in health, academic goals and capacity and capability' [Participant 2].

'*Health Informatics must be a recognised speciality in Health'* [Participant 5].

'Through their hands-on experiences and y reader wider on the topic - prescribing a prerequisite list of articles on topics that have to be read and analysed and presented before admission can be gained. Focus and apply African type of case studies and examples on all course materials. Focus on visionary documents on health and wellbeing – National Development Plan and Digital Health Strategy' [Participant 7].

'It is important not to apply one size fits all to the African context because of the peculiar context and varying economies' [Participant 8].

'Practitioners should not lose sight of paper based components of systems and work in hybrid environments' [Participant 11].

'Much emphasis is on what happens when the students do not have the infrastructure. Offline resources should be considered, podcasts, flash drives, paper not real-time learning' [Participant 11].

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4 Discussion

4.1 Objective 1: To explore competency needs of ICT Students and practitioners for developing Health ICTs with the involvement of healthcare practitioners as part of their work activities in practice

While there is a paucity in literature on Health Informatics Competencies for IT students, there are IT practitioners whose work has been in the health field and are able to determine the domain knowledge that is necessary for IT practitioners to be able to work within the health field. The results from the data collected from the Health Informatics experts indicate that there are several key competency considerations for Informatics practitioners at different levels of study. This may be at 1st year, Diploma, 3rd year and 4th year level. These stages form the critical stages of formative and evaluative learning of an Informatics student's career and have the following characteristic competency needs:

There are seven competencies that the experts felt were necessary for Students who have done either the 3-year course or a Diploma course. These were: Introduction to Health Informatics; Governance and Policy in HI; Governance and Management of HI; Ethics in HI; The Health Provision Context; Healthcare Knowledge in HI; Health Information Systems Reliability; and Logical Use and Patient Centric Development of Digital Solutions. These competencies form core factors that guide in the decision-making process for the implementation of Health ICT systems and eHealth Systems. In both the IMIA and HIT Comp, it is noted that an overview of the Health Informatics Context is necessary, IMIA indicates that this needs to include the evolution of the profession as a discipline. In each domain specific contexts, there are rules that guide in the governance, ethics and context of development of those domains systems. Although the IT domain contains rules that govern the development of ICT Systems, an understanding of the rules in the health domain, enables the development of relevant and sustainable Health ICT Systems. In the 4-year course these competencies, experts suggested should be staggered across the years, indicating that content evolves from a generalised overview in the first year to more specialised content.

Contextual orientation of the content of the competencies according to suggestions from the experts is health oriented. The competencies suggested had three characteristics: (1) A broad overview of the health domain context; (2) An overview of the Health System of the context, for example the Road to Health System that is used in South Africa; and (3) Health ICT Systems Software Modules. This is indicated by the suggestions for example of in Data Analysis to improve care provision, and in the Systems Development Life Cycle there is for example Patient Centric Development of Digital Solutions. Within the Systems Development Life Cycle the Backend competency was explicitly indicated in the HIT Comp with examples of Health Level 7 and Health Information Exchange being described and discussed. However, in the African Context experts mentioned the District Health Information Systems2 (DHIS2) and Open HIE as backend systems that are necessary for Students to know.

The competencies suggested are centred around Health Informatics Data, Data Management and Health Practise Workflows. These competencies characteristics complement the IT student's knowledge, as in order to develop systems for a context, domain knowledge on the data and the decisions made on that data is important. IT practitioners core work is in the implementation of systems, this not only requires the development of the IT artefact that will be used in the context, but also includes the data and information contained in the artefact. Mantas and Hasman (2017) note that this would ensure implementation of resilient Health ICT Systems. In order to have good data and information quality, having some domain knowledge, would guide IT students and practitioners on eliciting software requirements, software and process modelling,

Competency topics suggested were on ICTs in Health, however there were some Health Knowledge competency topics that the experts mentioned. These included content in Health, Health Workflow practice, Public Health and Epidemiology. This indicates that within the Health Field there are some Health knowledge topics that an IT student or practitioner would need to know. Although the IMIA framework has Health Specific Knowledge for IT practitioner, these are centred around the workflow practice of the health practitioner and are recommended for the IT practitioner to have an introductory knowledge of the topics. Topics like Public Health are not recommended although they are present. It has been traditionally assumed that IT practitioners do not need any Health knowledge and require only domain experts to be able to develop and suggest ICT systems within the health context. The expert's suggestion of these topics shows that this is not the case. As there is a paucity of Health practitioners, and an excess of work that they need

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to do, having IT practitioners that are knowledgeable with some Health knowledge, lessens the burden of time spent on collaboration for the development of artefacts. This is also noted by Martikainen et al.,[1]. IT practitioners have been noted to work in the Health Domain in the roles of Data Capturers, Developers, Support, and Entrepreneurship. Having Health domain Knowledge may provide opportunities for more roles that IT practitioners can play, especially for those who are not scientifically strong.

4.2 Objective 2: To explore how Informatics education can be designed to incorporate healthcare domain knowledge in the training of ICT practitioners.

For problem-based education like in Health Informatics Education, where transdisciplinary characteristics need to be considered, there are important design factors that need to be considered. As one expert noted that the notion of one size fits all does would not apply for Health Informatics Education, as there are varying needs, the “particular context and economies”. Considerations on education would need to done to determine the best method of administering a course for diverse student backgrounds. When asked to recommend a method of administering a Health Informatics Course for IT students, experts suggested six methods. These were: (1) Through a regulated 3- or 4-year course; (2) Short Online Course; (3) Winter or Summer School; (4) Hands on Experience; (5) Reading; (6) Shared learning experience with experts. Other than the regulated course and Winter and Summer Schools, the other four methods accommodate the IT practitioner, whose work practice does not allow for time off. This provides IT practitioners who are working with opportunities to upskill themselves within a particular domain.

On the focus, objective and depth of content of a course, it is noted that the following contextual characteristics are of importance: (1) Keeping a note of both national and international political situations and priorities, aid in keeping abreast with the contextual changes that affect the domain and relevancy of the Health Informatics Education Offering.

(2) In the African Context, course content should “focus and apply African type of case studies and examples", this makes the content visually meaningful to the students. The African health context provides a platform for the development of HIS artefacts that can be used in remote areas. In the African context eHealth, telehealth and mHealth are the common systems that IT practitioners implement especially for remote area contexts. Kokol et al [36] notes that this is the strength domain of IT practitioners working Health contexts, while Health Informatics is a strength for Health practitioners. Case study examples provides Informatics Students with an understanding of the process of implementing relevant artefacts within the context of Health.

(3) It is important for informatics students to know and understand the ‘paper-based components’ used within their context of health. These would aid the students in understanding the context of health, the type of data that health practitioners capture as they conduct their praxis and enable them to gain an overview of the activity workflow touch points, the stakeholders that use that data, the user rights to the data, the decisions made using that data and security measures that need to be implemented to protect that data. Content should also include the health documents from the country or context in which the course is to be administered.

(4) Hands on experience is important, and involvement in an initiative either governmental or non-governmental aids in providing platforms from which students can practice their competencies.

(5) For content that is focused on the development of Health Systems, it is important to note that Health IT artefacts have domain specific data standards that they implement for the Systems databases. It is important that Informatics students learn the data standards, and backend components. These differ according to national context as well as context of practice. Common data standards that are particularly used within Africa are the DHIS2, HL7, SNOMED and other components that are used in the development of Health Information Systems Architecture.

5 Conclusion

The study revealed that there is some domain knowledge that is specific for Informatics Students and Practitioners to know. Key competency topics were identified by experts and considered as important for Undergraduate Informatics Students to learn. The suggestion of topics at different academic levels that

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could be taught, aids in identifying competencies that could be recommendations for a course that could be offered to Informatics students. Some knowledge in Health Informatics topics further provides interdisciplinary skills to undergraduate students that may not have or otherwise would have had such skills. Having Health domain Knowledge may provide opportunities for more roles that IT practitioners can play, especially for those who are not scientifically strong. Further research involving identification of skills from the Health Informatics practitioners' praxis could be conducted to identify touch points in their workflow, as well as the roles that IT practitioners may play in the Health Field.

6 Limitations

One of the limitations of our study was the small sample size. This was addressed by the fact all participants are highly regarded experts. Limitations on bias towards the field of informatics was addressed by having participants with both informatics and health backgrounds, hence a fair portrayal of the discipline is obtained.

7 Ethics

The necessary ethics clearance was obtained from the Health Informatics experts and the University under which this study was conducted.

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Statement on conflicts of interest

No conflict of Interest

References

[1] Martikainen S, Kaipio J, Lääveri T. End-user participation in health information systems (HIS) development: Physicians' and nurses' experiences. Int J Med Inform [Internet]. 2020;137(February):104117. Available from: https://doi.org/10.1016/j.ijmedinf.2020.104117
[2] Mantas J, Hasman A. IMIA Educational Recommendations and Nursing Informatics. Stud Health Technol Inform. 2017 Jan 1;232:20–30.
[3] Ahmad MM, Musallam R, Allah AH. Nurses and internet health-related information: review on access and utility. 2018;91(3):266–73
[4] Mahoney DF, Faan BC. The aging nurse workforce and technology Aging nurse workforce. 2011;10(1)
[5] Farahat TM, Hegazy NN, Mowafy M. Information and communication technologies in primary healthcare facilities in Egypt. 2020;88–95
[6] Hersh W, Margolis A, Quirós F, Otero P. Building a health informatics workforce in developing countries. Health Aff. 2010;29(2):275–8.
[7] Murphy J, Goossen W, Weber P. Forecasting Informatics Competencies for Nurses in the Future of Connected Health. Nursing Informatics Post Conference. 2017
[8] Wesolowski A, O'Meara WP, Tatem AJ, Ndege S, Eagle N, Buckee CO. Quantifying the impact of accessibility on preventive healthcare in sub-Saharan Africa using mobile phone data. Epidemiology. 2015;26(2):223–8
[9] Health Systems Trust. Health Indicators [Internet]. 2021. Available from: https://www.hst.org.za/healthindicators
[10] Korpela M, Mursu A, Soriyan HA, de la Harpe R, Macome E. Information systems practice for development in Africa: Results from INDEHELA. IFIP Int Fed Inf Process. 2006;208:15–35.
[11] Wright G. Some Thoughts about Health Informatics in Africa. Eur J Biomed Informatics. 2018;14(1):75–6
[12] van Stam G. Framing "ICT Access in Rural Africa." 11th Prato CIRN Conf 13-15 Oct 2014, Prato, Italy [Internet]. 2014;(Ci). Available from:

https://www.researchgate.net/publication/266154055_Framing_%27ICT_Access_in_Rural_Africa%27

[13] Fernández E. Innovation in Healthcare : Harnessing New Technologies Innovation in Healthcare : Harnessing New Technologies. 2017;2017(2)

[14] Avgerou C. Information systems in developing countries: A critical research review. J Inf Technol. 2008;23(3):133–46

[15] Lawler J, Joseph A. Entrepreneurial Health Informatics for Computer Science and Information Systems Students. 2014;12(January):27–41

[16] Longenecker HE, Campbell SM, Landry JP, Pardue H, Daigle RJ. A Health Informatics Curriculum Congruent with IS 2010 and IMIA Recommendations for an Undergraduate Degree. 2012;10(April):15–32.

[17] Herselman M, Botha A. Strategies , Approaches and Experiences : Towards building a South African Digital Health Innovation Ecosystem. 2016.

[18] Roach S, Sahami M. CS2013: Computer Science Curricula 2013. Vol. 48, Computer. 2015. 114–116 p.

[19] Murić G, Abeliuk A, Lerman K, Ferrara E. Collaboration Drives Individual Productivity. 2019;3(November).

[20] Sharp H, Plonka L, Taylor K, Gregory P. Overcoming Challenges in Collaboration between Research and Practice : The Agile Research Network. 2014;10–3.

[21] Svensson A. Challenges in Using IT Systems for Collaboration in Healthcare Services. 2019;

[22] Mihalas GI. Evolution of Trends in European Medical Informatics. 2014;22(1):37–43.

[23] Ngafeeson M. Healthcare Information Systems : Opportunities and Challenges Encyclopedia of Information Science and Technology , Third Edition. 2014;

[24] Sittig DF, Bates DW. Current challenges in health information technology – related patient safety. 2020;(2).

[25] Heeks R. Health information systems : Failure , success and improvisation. 2006;

[26] Tscholl DW, Handschin L, Rössler J, Weiss M, Spahn DR, Nöthiger CB. It ' s not you , it ' s the design - common problems with patient monitoring reported by anesthesiologists : a mixed qualitative and quantitative study. 2019;1–10.

[27] Campbell SM, Pardue JH, Longenecker HE, Barnett H Les, Landry JP, Circle A. Treating the Healthcare Workforce Crisis : A Prescription for a Health Informatics Curriculum. 2012;10(June):35–46.

[28] Gadd CS, Steen EB, Caro CM, Greenberg S, Williamson JJ, Fridsma DB. Domains, tasks, and knowledge for health informatics practice: Results of a practice analysis. J Am Med Informatics Assoc. 2020;27(6):845–52.

[29] Bernstam E V., Tenenbaum JD, Kuperman GJ. Preserving an integrated view of informatics. J Am Med Informatics Assoc. 2014;21(E2):1–2.

[30] Matney SA, Langford LH, Staggers N. Are nursing informatics competencies good enough? JBI Evid Synth. 2021;19(4):747–8.

[31] Valenta AL, Berner ES, Boren SA, Deckard GJ, Fridsma DB, Gadd C, et al. Perspective AMIA Board White Paper : AMIA 2017 core competencies for applied health informatics education at the master ' s degree level. 2018;25(October):1657–68.

[32] Shaw T, Blake R, Hübner U, Anderson C, Wangia-Anderson V, Elias B. The Evolution of TIGER Competencies and Informatics Resources | HIMSS. Healthc Inf Manag Syst Soc [Internet]. 2017; Available from: https://www.himss.org/library/evolution-tiger-competencies-and-informatics-resources%0Afile:///Users/beatrice_cutie/Downloads/The Evolution of TIGER Competencies and Informatics Resources FINAL 10.2017.pdf

[33] Mantas J, Ammenwerth E, Demiris G, Hasman A, Haux R, Hersh W, et al. Recommendations of the International Medical Informatics Association (IMIA) on Education in Biomedical and Health Informatics. Methods Inf Med. 2010;49(02):105–20.

[34] Bruggeman B, Tondeur J, Pynoo B, Struyven K. Experts ' Insights About Blended Learning Implementation : What Teacher Attributes are Relevant ? 2018;(2011).

[35] Mothupi MC, Knight L, Tabana H. Improving the validity, relevance and feasibility of the continuum of care framework for maternal health in South Africa: A thematic analysis of experts' perspectives. Heal Res Policy Syst. 2020;18(1):1–14.

[36] Kokol, P., Saranto, K., & Blazun, H. (2018). eHealth and health informatics competences: A systemic analysis of literature production based on bibliometrics. *Kybernetes, 47*, 1018-1030.

Journal of Health Informatics in Africa

Systematic Literature Review on Opportunities for Digital Innovation in the Healthcare Sector

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Background and Purpose: The concept of digital innovation has garnered significant attention recently and has the potential to revolutionise industries. With the recent advancements in healthcare and the emergence of new digital technologies, this manuscript reports the results of a systematic literature review (SLR) aimed at identifying the opportunities that digital innovation can afford the healthcare sector. These opportunities could guide policymakers and healthcare practitioners in making informed decisions regarding the implementation of digital innovation in healthcare.
Methods: This study conducted a systematic literature review (SLR) that involved defining the purpose of the literature review, establishing inclusion and exclusion criteria, identifying data sources and search strategies, screening and determining eligibility, and making inclusion/exclusion decisions. This study also included quality assessment criteria to evaluate the selected publications. 1478 research papers were analysed using descriptive statistics and thematic analysis to identify themes from the papers included in the SLR.
Results: The findings presented nine themes related to opportunities for digital innovation in healthcare. The following themes were discussed: precision/personalised medicine/healthcare, interoperability, privacy, and security, improved decision-making process, real-time/remote monitoring, enabling new processes/services/products, training/education, knowledge acquisition/sharing, and other themes that could not be categorised. These themes include cost, effectiveness, and time management.
Conclusions: This study utilised thematic analysis to examine the themes that emerged from the findings. These themes centred around the opportunities for digital innovation in healthcare. Awareness about each opportunity for digital innovation in healthcare is discussed. This study discussed the limitations of this SLR and future research opportunities for policymakers and healthcare practitioners wanting to implement digital innovation in healthcare.

Keywords: Digital Innovation Opportunities, Healthcare, Systematic Literature Review

1 Introduction

With the emergence and advancement of technology, the concept of digital innovation has garnered significant attention in both research and practice [1]. The healthcare sector has faced pressure from various stakeholders, including healthcare providers, non-governmental organisations, physicians, medical practitioners, academics, regulators, policymakers, and patients to improve the quality of healthcare service delivery [2] [3]. There is a pressing need to enhance the quality of healthcare services considering the numerous challenges confronting the global health system. The challenges include access to affordable healthcare, a decline in living standards, an increase in the prevalence of life-threatening conditions, and a rise in the incidences of deteriorating health conditions [4] [5]. There is a growing need to explore the potential of digital innovation to transform and enhance the healthcare sector [4] [6]. According to Jha and Bose [6], digital innovation is the new wave of organisational, technical, and cognitive innovation practices that follow the digitalisation of physical artefacts. According to Lyytinen et al. [7], digital innovation is the creation of new combinations of digital and physical components to produce new products. According to Khan and Tariq [8], digital innovation is an idea, practice or object that is considered new and embodied in and enabled by digital technology. Considering the various definitions of digital innovation [6] [7] [8], this

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study adopts the definitions [7] [8] and refers to digital innovation as the combination of digital inventions, products, processes, and service innovations, as well as new ideas, their adoption, and diffusion which are facilitated by digital technology.

Some potential benefits of digital innovation in healthcare, such as easy access to complex data, cost savings, improved patient experience, and real-time monitoring, have not been adequately demonstrated in the implementation of new generations of digital innovations [4] [9]. The recent advancements in digital technologies, such as cloud computing, artificial intelligence, 3D printing, 5G Technologies, Internet of Things (IoT), Internet of Medical Things (IoMT), blockchain, and big data, present opportunities for digital innovations in healthcare [10] [11]. These technologies have the potential to transform and revolutionise how medical practitioners, policymakers, and patients manage healthcare services, processes, and products [12].

The nature of healthcare services requires interactions among various stakeholders at different levels of the organisation, all working towards a shared goal of improving patient well-being [12] [13]. Furthermore, challenges such as designing digital innovations for healthcare, conceptualising healthcare innovation products, standardising devices, and integrating with new technologies have led healthcare stakeholders to explore potential opportunities for digital innovation [14]. The lack of distinction between healthcare practices and knowledge has hindered the identification of potential opportunities for digital innovation implementation in healthcare [2] [15]. Healthcare practitioners and policymakers are realising the need to transform healthcare practices and promote advanced services that can respond to the needs of society and patients [16] [2] [11].

This manuscript presents the results of a study aimed to synthesise the different opportunities for digital innovation in healthcare that could guide policymakers and healthcare practitioners in making informed decisions about implementing digital innovations to enhance the quality of healthcare service delivery. The remaining sections of the manuscript are as follows: the materials and methods are outlined in section 2, followed by the results of the analysis in section 3. The discussion of results is presented in section 4, followed by the concluding remarks and future research in section 5.

2 Materials and methods

This study aims to synthesise and present a list of opportunities for digital innovation in healthcare. To achieve this, research articles were retrieved from the following database sources based on their quality and rating as high-impact research journals and conference papers: IEEE Xplore, PubMed, ScienceDirect, and SpringerLink. To ensure that only the relevant papers were retrieved, keywords were combined with the Boolean operators ‘OR’ and ‘AND’ and the wildcard ‘*’ (Digital innovation* AND Opportunities AND Healthcare ‘OR’ Health Innovation* AND Healthcare innovation opportunities). The inclusion and exclusion criteria used in this review were summarised in Table 1:

Table 1: Inclusion and Exclusion criteria

Inclusion criteria	Exclusion criteria
Studies that were published in English.	Sources that were not peer-reviewed.
Studies that were published between 2010 and 2022.	Sources whose reported outcomes did not focus on the opportunities for digital innovation.
Peer-reviewed studies (journals, conference proceedings, and book chapters).	Sources that were not aligned with this SLR's main purpose.
Studies that were aligned with this SLR’s main purpose.	Duplicate studies were excluded.

The systematic literature review was conducted between August and September 2022. A total of 1478 publications were retrieved from the four database sources. An additional 475 publications were retrieved from other sources, namely Scopus, Google Scholar, Web of Science, JSTOR, and ProQuest Central. After

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removing 712 duplicate publications, a total of 1171 publications were excluded based on the exclusion criteria set in this study. A total of 70 publications were screened, and at the end of the selection process, 43 publications were subjected to quality assessment questions. The quality assessment questions used in this study were as follows:

- Quality Assessment (QA)1: Does the research include a description of opportunities for digital innovation?
- QA2: Does the research explore themes/concepts relating to digital innovation?
- QA3: Does the research adequately document digital innovation opportunities in healthcare?

A publication was assigned a score of 1 if it met the QA criterion fully, 0.5 if it met the QA criterion partially, and zero if it did not meet the QA criterion at all. A publication had a maximum score of three if it met all three QA criteria. Only publications that partially or fully met the descriptions of the questions were considered. From 43 publications subjected to the QA questions, 12 sources were excluded, and 31 research papers were considered for final inclusion in this SLR. Figure 1 illustrates the source selection process.

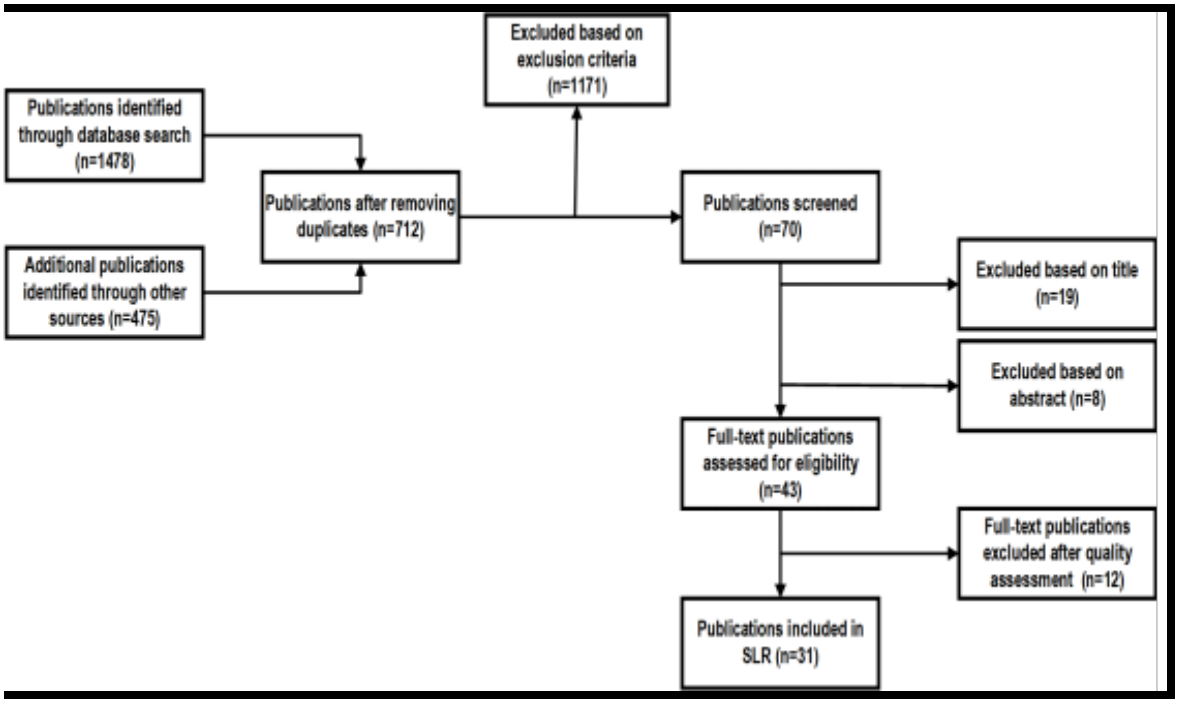

Figure 1: Source selection process

3 Results

The results were analysed based on the distribution of publications per database source, the year of publication, and the research methods employed. Descriptive statistics were used to summarise data on the distribution of publications. In this research, a thematic analysis was conducted to group the themes and concepts that emerged from the publications presented in Appendix Table 1. Thematic analysis is concerned with classifying and representing themes and patterns that relate to data [17]. According to Creswell and Clark [17], a thematic analysis is an active process that involves reading a set of data in which the researcher's subjectivity is at the centre of making sense of the data.

In this analysis, themes related to opportunities for digital innovation in healthcare were identified throughout all these publications. These concepts were grouped following the main themes that emerged, then reviewed, and later defined. The decision to select the thematic analysis was informed by the ability of the technique to allow the researchers to detect and identify concepts of digital innovation opportunities

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in healthcare. The choice of the technique was also informed by the opportunity afforded to researchers to understand the current practices of those involved in the use and implementation of digital innovation in healthcare and their ability to summarise data and make the necessary comparison between various publications.

3.1 Distribution per database sources

The analysis of the research papers according to their distribution per database sources is presented in Table 2:

Table 2: Distribution of publications per database source

Database sources	The number of publications	% of publications
IEEE	9	29%
PubMed NCBI	8	26%
ScienceDirect	7	23%
Springer	2	6%
(Others=Scopus, Google Scholar, Web of Science, DOAJ, JSTOR, and ProQuest Central)	5	16%
TOTAL	31	100%

The analysis of the publications per database sources revealed that 29% of publications came from the IEEE database source, followed by 26% of publications from the PubMed NCBI database source, followed by 23% of publications from the ScienceDirect database source. 16% of publications came from other sources combined and these included Scopus, Google Scholar, Web of Science, DOAJ, JSTOR, and ProQuest Central. The analysis further revealed that 6% of the publications included in this SLR came from the Springer database source. All the publications included in this SLR met the inclusion criteria set in this study. The contributions from these publications provided researchers with a lens to identify the opportunities for digital innovation in healthcare, which were further aligned with this SLR's objectives.

3.2 Distribution of publications by year

The analysis of the research papers according to their year of publication is presented in Table 3:

Table 3: Distribution of publications by years

Year	The number of publications (%)	Citations
2014	2 (6%)	[18] [19]
2015	1 (3%)	[20]

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2016	1 (3%)	[21]
2017	2 (6%)	[1] [22]
2018	2 (6%)	[3] [23]
2019	5 (16%)	[24] [25] [26] [27] [28]
2020	5 (16%)	[29] [30] [31] [32] [33]
2021	9 (29%)	[12] [14] [34] [35] [36] [37] [38] [39] [40]
2022	4 (13%)	[41] [42] [43] [44]
TOTAL	31 (100%)	

The analysis of the research papers according to the year of publications revealed that two publications were published in 2014, this was followed by one publication in 2015 and the other in 2016. Two publications were published in 2017, followed by two publications in 2018. The analysis also indicated five publications were published in 2019, followed by five publications in 2020. From 2019 to 2021, the number of publications addressing the opportunities for digital innovation increased. The analysis of the publications per year further showed that there was a dip between 2021 to 2022.

3.3 Distribution of publications by research methodology

The findings of the publications presented two research methodologies, namely, studies that followed qualitative research and studies that followed the quantitative research method. The findings also included publications that did not indicate any research method. The distribution of publications by research methodology is summarised in Table 4.

Table 4: Distribution of publications by research methodology

Research method	**The number of publications**	**Citations**
Qualitative	16	[1] [43] [3] [20] [18] [25] [14] [37] [29] [28] [24] [33] [36] [22] [42] [23]
Quantitative	4	[44] [21] [19] [31]
Unspecified	11	[34] [35] [32] [38] [12] [26] [39] [1] [40] [41] [30]

Thematic analysis was used to gather themes and concepts that emerged from the findings. The themes and concepts that emerged from the findings revolved around opportunities for digital innovation in healthcare and are presented in Appendix Table 1.

4 Discussion of Results

The analysis enabled the researchers to identify the opportunities for digital innovation in healthcare and provide a detailed description of these opportunities for digital innovation in healthcare as found in

Appendix Table 1. After conducting the thematic analysis, similar themes were grouped, and nine themes related to the opportunities for digital innovation in healthcare were identified.

4.1 Precision/personalised medicine/healthcare

The emergence of large-scale health information system initiatives using data from various sources has led to the development of precision or personalised medicine. This approach uses patient data and profiles, along with other analytics, to provide tailored products or services [45]. The approach is considered an advanced analytical technique, as it uses deep learning models to advance precision medicine due to its ability to process large amounts of diverse data with greater accuracy [45].

With the advancements in healthcare, precision medicine is now capable of making use of digital innovations to revolutionise the future of healthcare. This is achieved by facilitating the usage of patients' genetics to select, diagnose, and provide personalised treatments for their conditions [23] [26] [37]. One notable advancement that was previously unattainable is the ability to verify healthcare prediction models or systems, which has been made possible by digital innovation in healthcare [20] [29] [32] [35] [37] [43]. Digital innovation has enabled healthcare practitioners to receive assistance in interpreting and verifying complex medical data analytics. This ensures that transparency and decision-making are not prone to errors or doubts [3] [35] [37].

There are opportunities to detect symptoms early and collect data through digital innovations in healthcare. This can be aided by the analysis of community health situations, including previous pandemic analytics [20] [29] [35] [37]. Through personalised medicine enabled by digital innovation, tailored healthcare services offer an opportunity for improved standards of living and increased productivity [42] [43]. Some digital technologies driving personalised medicine are 5G Technologies, AI, Cloud Computing, the Internet of Things (IoT), and the Internet of Medical Things (IoMT) [3] [25] [26] [42] [43].

4.2 Interoperability

Interoperability plays a crucial role when two or more platforms need to exchange health information. It ensures that the information is received and translated into a format that can be understood by the receiving system or device [46]. With various overlapping functionalities in healthcare for exchanging patients' data, interoperability is necessary to harmonise healthcare solutions and facilitate communication to provide the necessary outputs [46]. Digital health technologies are examples that are said to promote interoperability in healthcare [24] [33] [40] [46]. One benefit of digital innovation is the potential for improved interoperability at the system level [24] [40].

With the advancements in digital innovation facilitated by healthcare technologies, interoperability occurs when essential requirements are met to enable the reliability and availability of health devices, and technical compatibility between various infrastructure and healthcare technology standards [24] [40]. There is an opportunity to align patients' data across organisational infrastructures to enable standards upon which further healthcare processes, services, and products can be built [22] [24] [40]. Another layer of contribution brought by digital innovation is the opportunity for aggregating medical data facilitated by digital health technologies [32]. Interoperability plays a crucial role in ensuring that different systems can communicate with each other seamlessly. Therefore, there is an opportunity to aggregate data from various digital technologies [32].

4.3 Privacy and security

With the increased connectivity of health information systems, the privacy and security of medical data and applications used to deliver services to patients have become critical components of the healthcare infrastructure [3] [20] [34] [44]. With the new advances in digital technologies, such as blockchain, big data, and the Internet of Things (IoT), so is the high level of sophistication brought about by these digital technologies to revolutionise how risks and threats posed to the healthcare infrastructure could be minimised [20] [26] [31] [34] [44]. Medical practitioners should consider the potential benefits of digital innovation facilitated by blockchain technology in providing an increased level of trust for managing

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medical infrastructures [34] [44]. The immutability of the ledger can be utilised to prevent tampering with medical data during transactions [20] [26] [44].

Digital innovation has presented an opportunity to reconsider the transparency of medical data, facilitated by digital technologies such as blockchain. This technology allows for the incorporation of a consensus method to verify medical records and transactions, which can address patients' relationships using distributed ledger technology [34] [44]. Digital innovation brings new opportunities for privacy and security, such as improving data quality, ensuring compliance, and enabling verification in healthcare [31] [42] [43]. These opportunities are driven by digital technologies such as artificial intelligence (AI), blockchain, and digital health technologies.

4.4 Improved decision-making process

The opportunities for digital innovation have expanded and now can improve decision-making efficiency in healthcare by utilising patient data and other data analytics [29]. Digital technologies such as artificial intelligence (AI), big data, digital health technologies and contactless services present new forms of digitalisation based on the massive use of data for knowledge extraction [29] [36]. These new forms of digitalisation enable the convergence of different areas of expertise to make better decisions and share information among various healthcare entities [25] [29] [36].

With the advent of digital innovation in healthcare, there is a convergence of diverse areas of expertise, resulting in more collaborative and distributed forms of cooperation among various stakeholders. This facilitates the sharing of information and enables better decision-making [25]. These forms of cooperation now involve closer involvement between stakeholders, the convergence of health processes, and improved coordination and communication among various healthcare entities [21] [25] [33] [36] [41]. The other aspect of this contribution to improving the decision-making process is the ability to measure the success of healthcare products and services [33]. According to Hein et al. [33], the success of healthcare services, products, and processes is not solely measured by their monetary value, but also by the collective responsibility and collaboration to solve problems and make informed decisions to execute plans for patient care.

4.5 Real-time / Remote monitoring

As patients increasingly demand quality healthcare services regardless of their location, there are opportunities to provide effective on-time medical support remotely [36] [43]. The advent of digital technologies such as 5G Technologies, AI, the Internet of Things (IoT), cloud computing, and digital health has created opportunities for medical practitioners to provide accurate interpretation of clinical tests remotely and analyse medical data in real-time [29] [36]. These digital technologies have further made it possible to provide accurate interpretations of clinical tests that align with appropriate treatments [21] [29] [36] [39].

There is also an opportunity for remote monitoring to manage patients' data by utilising medical data from various sources. This data can be further analysed using a query to profile cases of patients who were previously tested [20] [35]. Furthermore, digital technologies enable mobility and scalability even when medical data is stored in stationary infrastructure [14] [20] [27] [41].

4.6 Enabling new processes, services, and products

This study emphasises the importance of digital innovation and highlights the potential for creating new patient-oriented services, processes, and products for both patients and healthcare entities [3] [43]. One important consideration to note is the potential for enhancing healthcare operational procedures that extend beyond the confines of the healthcare industry [3] [25]. Improved operational procedures in healthcare are being driven by digital technologies such as blockchain, big data, the Internet of Medical Things (IoMT), cloud computing, and digital health technologies [3] [12] [25] [43].

The use of big data and AI in healthcare is believed to drive digital innovation and improve health processes. Healthcare practitioners can leverage health outputs, advanced health analytics tools, and

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insights to develop successful strategies that aim for better outcomes and improved patient experiences at lower costs [3] [12]. Furthermore, the advent of digital innovation, including 5G Technologies, IoT, cloud computing, and big data, presents new opportunities to enhance data processing capabilities. These technologies enable the collection, aggregation, cleaning, and updating of medical data, which can inform strategic decisions regarding medical treatments, interventions, and procedures [12] [14].

According to Mackey et al. [26] and Javaid et al.[41],digital innovation facilitated by technologies such as blockchain, IoT, IoMT, contactless services, and digital health technologies creates an opportunity to integrate and automate healthcare processes. Digital health technologies, such as 5G Technologies, IoT, IoMT, and cloud computing, have opened new doors for healthcare practitioners to closely examine the services, processes, and products that could be improved to ensure their sustainability more efficiently [33] [25] [43]. Moreover, the implementation of digital health technologies has enabled digital innovation, which is expected to introduce new capabilities for redesigning healthcare business models and optimising healthcare resources to meet patients' expectations. This in turn will help healthcare entities capture the necessary value for long-term sustainability and improve patients' well-being [27] [33] [34] [41] [44].

4.7 Training/Education

The advent of digital health technologies, big data, and contactless services has facilitated digital innovation, providing opportunities to acquire the knowledge and training necessary to drive new healthcare services, processes, and products [8] [27] [43]. With the advances in digital innovation, it has become crucial to train and educate healthcare professionals [27]. According to Kucharska [8] and Saraswat et al. [43], there is a growing need to train and educate healthcare professionals to ensure they have a shared understanding of the team's approach to managing new services, processes, and products for the well-being of patients. This includes developing shared knowledge, skills, and attitudes.

4.8 Knowledge Acquisition/Sharing

Knowledge is a process of exchanging information, expertise, and feedback to create new ideas and knowledge [27] [43] [45]. Knowledge has become critical in healthcare for effectively achieving common goals and making important decisions [27] [43] [45]. To take advantage of the opportunities presented by digital innovation, facilitated by digital health technologies and contactless services, knowledge acquisition and sharing in healthcare is crucial [8] [43]. Healthcare managers and decision-makers must equip stakeholders with the necessary tools to ensure that decisions made in healthcare are well understood and supported [8] [43]. Furthermore, the advancement of digital technology in healthcare, including digital health technologies and contactless services, necessitates the acquisition of new knowledge. This opens up new opportunities to facilitate and create innovative ways of sharing and storing knowledge [43].

4.9 Additional themes

In this analysis, some themes that could not be grouped were discussed individually. Digital innovation has brought several contributions to the healthcare industry, including the opportunity for stakeholders to become more cost-savvy by eliminating high-risk fraud and duplication of services or processes where applicable, by using blockchain technology [21] [44]. One of the features of blockchain technology, such as a decentralised medical database system, is said to play a critical role in eliminating high-risk fraud and duplication of services and processes in healthcare [1] [21] [28] [30] [44]. Digital health technologies have brought about various contributions, including increased flexibility for medical practitioners to organise their time more effectively and manage tasks more intelligently. This has resulted in reduced time spent analysing patients' data and making necessary recommendations and clinical decisions [29] [41].

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5 Conclusion and future research

Identifying the appropriate digital innovations facilitated by digital health technology and aligning them with the need to improve the quality of healthcare services is not without challenges. This study identified nine themes related to opportunities for digital innovation in healthcare. These opportunities provide insights into the advancements in digital innovation that healthcare practitioners and policymakers can consider to improve the quality of healthcare services.

The findings of this study offer a valuable classification system for understanding the potential opportunities for digital innovation in healthcare. Choosing the most appropriate digital innovation for a specific healthcare setting can be a complex decision. However, the themes identified in this study provide a starting point for policymakers and healthcare practitioners looking to improve the quality of healthcare services. The detailed exploration of each theme related to digital innovation opportunities enables healthcare and policymakers to choose the most appropriate digital innovations facilitated by digital technology to implement in healthcare.

This SLR also highlights potential areas for future research. While exploring themes related to the opportunities for digital innovation in healthcare, this study identified limitations in conducting this SLR. This SLR was conducted from August to September 2022, and this study recommends that future research extend the search period to further explore opportunities for digital innovation in healthcare. This SLR identified four database sources: IEEE Xplore, PubMed, ScienceDirect, and Spring Link. Additionally, Google Scholar, Web of Science, JSTOR, and ProQuest Central were also considered for identifying relevant publications. However, it is important to note that the limitation of this SLR lies in the fact that the identification process was limited to these sources, potentially excluding valuable insights from other sources related to digital innovation opportunities in healthcare. Furthermore, the exclusion criteria used in this SLR may have limited the exploration of additional opportunities for digital innovation.

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Statement on conflicts of interest

No conflict of interest

References

[1] Nambisan S and Nambisan P. How should organisations promote equitable distribution of benefits from technological innovation in health care?, *AMA Journal of Ethics*, vol. 19, no. 11, pp. 1106–1115, [Online]. available: https://journalofethics.ama-assn.org/sites/journalofethics.ama-assn.org/files/2018-05/stas1-1711.pdf

[2] Klecun E. Transforming healthcare: policy discourses of IT and patient-centred care, *European Journal of Information Systems*, vol. 25, no. 2016, pp.64–76, 2016, doi: 10.1057/ejis.2014.40

[3] Tyrvainen P, Silvennoinen M, and Lamberg KT. Identifying Opportunities for AI Applications in Healthcare-Renewing the National Healthcare and Social Services, *IEEE*, pp.1–7, 2018, doi: 10.1109/SeGAH.2018.8401381

[4] Dondofema RA and Grobbelaar SS. Conceptualising innovation platforms through innovation ecosystems perspective, *IEEE International Conference on Engineering, Technology, and Innovation (ICE/ITMC)*, pp. 1–10, 2019, doi: 10.1109/ICE.2019.8792668.

[5] Dougherty LC and Kleinman D. Assessing quality improvement in health care: Theory for Practice, *Pediatrics*, vol. 131, pp.110-119, 2018, doi: 10.1542/peds.2012-1427n.

[6] Yusif S, Hafeez B, and Soar J. E-health readiness assessment factors and measuring tools: A systematic review, *International Journal of Medical Informatics*, vol. 107, no. 2017, pp. 56–64, 2017, doi: 10.1016/j.ijmedinf.2017.08.006

[7] Lyytinen K, Boland J, and Yoo Y. Digital Innovation within four classes of innovation networks, *Information Systems Journal,* vol. 25, no. 1, pp.1-4, 2016, doi: 10.1111/isj.12093

 J Health Inform Afr. 2024;11(1):33-50. DOI: 10.12856/JHIA-2022-v11-i1-463

[8] Kucharska W. Tacit knowledge influence on intellectual capital and innovativeness in the healthcare sector: A cross-country of Poland and US, *Journal of Business Research,* vol. 149, no. 2022, pp. 869-883, 2022, doi: 10.1016/j.jbusres.2022.05.059

[9] Khan AN and Tariq MK. Attributes of 'Diffusion of Innovations' of business products (Review Paper), *International Journal of Information, Business and Management*, vol. 10, no. 3, pp.1–14, 2018, [Online]. available:https://d1wqtxts1xzle7.cloudfront.net/57201166/IJIBM_Vol10No3_Aug2018-libre.pdf?1534464205=&response-content-disposition=inline%3B+filename%3DProfit_and_Practice_Online_Shopping_Cent.pdf&Expires=1686206013&Signature=RQSslLEZgQq9jd9AZTYpl8-s8HOMkK1F2MzUHuaN1NsxsCHeIAbALnoI6XEnLXtsitiQOe5GRP8bjIjU9BNv5Ns1kdaUbwZUSFy2uAt6LxQBBko2O7zojsHRvhgreripiDIBJeLmixBeZ47VTV27jafholRLvDEqnbWfbdLlzFayb8P10fU35qzFAcxZGatv-usAYeK4v2f4c6Vct227nZCO33YvZbUvdX2grr4gRYbmMEfyX-K-z-WXQmYUoUjLdZffYq~MTD7pPvNdmDMQIt8hHdtic2fzUbY5Ec9IE7ejnONCJTgHKrMcEiLAw~SN9q0OLGETfoo5LV-ME0OGkA__&Key-Pair-Id=APKAJLOHF5GGSLRBV4ZA#page=6

[10] Leonard E, de Kock I, and Bam W. Investigating the relationships between health and innovation systems to guide innovation adoption, *2019 IEEE International Conference On Engineering, Technology, and Innovation*, pp.1–10, 2019, doi: 10.1109/ICE.2019.8792677

[11] Wiesbock F and Hess T. Digital innovations: Embedding in organisations, *Electronic Markets*, vol. 30, no. 2020, pp. 75–86, 2020, doi:10.1007/s12525-019-00364-9

[12] Ciarli T, Kenney M, Massini S, and Piscitello L. Digital technologies, innovation, and skills: Emerging trajectories and challenges, *Research Policy*, vol. 50, no. 2021, pp. 1–10, 2021, doi: 10.1016/j.respol.2021.104289.

[13] Doward AR. Livelisystems: A Conceptual framework integrating social, ecosystem, development, and evolutionary theory, *Ecology and Society*, vol.19, no. 2, pp.1–14, 2014, 10.5751/ES-06494-19244.

[14] Georgiou KE, Georgiou E, and Satava RM. 5G Use in Healthcare: The Future is Present, *Journal of the Society of Laparoscopic and Robotics Surgeons*, vol. 25, no.4, pp.1–22, 2021, doi: 10.4293/JSLS.2021.00064.

[15] Holmstrom J. Recombination in digital innovation: Challenges, opportunities, and the importance of a theoretical framework, *Information and Organisation*, vol. 28, no. 2018, pp. 107–110, 2018, doi: 10.1016/j.infoandorg.2018.04.002

[16] Das P, Verburg R, and Bonebakker L. Barriers to innovation within large financial services firms: An in-depth study of disruptive and radical innovation projects at a bank, *European Journal of Innovation Management*, vol. 21, no.1, pp. 96–112, 2018, doi: 10.1108/EJIM-03-2017-0028.

[17] Creswell JW and Clark VLP. *Designing and conducting mixed methods research*. Los Angeles: Sage Publications, 2017.

[18] Brown C, Jensen TB, Aanestad M, and Currie W. Leveraging digital innovation in healthcare: Harnessing big data, cloud, and mobile computing for better health, *Association for Information Systems AIS Electronic Library (AISeL) ECIS 2014 Proceedings*, 2014, [Online]. Available: https://www.researchgate.net/profile/Margunn-Aanestad/publication/263642073_Leveraging_Digital_Innovation_in_Healthcare_Harnessing_Big_Data_Cloud_and_Mobile_Computing_for_Better_Health/links/566a944a08aea0892c4a14b2/Leveraging-Digital-Innovation-in-Healthcare-Harnessing-Big-Data-Cloud-and-Mobile-Computing-for-Better-Health.pdf

[19] Thomas GJ and Bond DS. Review of Innovations in Digital Health Technology to Promote Weight Control, *Curr Diab Rep*, vol. 14, no. 485, pp. 1–10, 2014, doi: 10.1007/s11892-014-0485-1

[20] Lim AK and Thuemmler C. Opportunities and Challenges of Internet-based Health Interventions in the Future Internet, *2015 12th International Conference on Information Technology-New Generations*, pp.567–573, 2015, doi: 101109/ITNG.2015.95

[21] Williams JS, Walker RJ, and Egede L. Achieving Equity in an Evolving Healthcare System: Opportunities and Challenges, *The American Journal of The Medical Sciences (Am J Med Sci)*, vol. 351, no. 1, pp. 33–43, 2016, doi:10.1016/j.amjms.2015.10.012

[22] Iyawa GE, Herselman M, and Botha A. Potential Stakeholders and Perceived Benefits of a Digital Health Innovation Ecosystem for the Namibian Context, *CENTERIS-International Conference on ENTERprise Information Systems / ProjMan- International Conference on Project MANagement /HCist-International Conference on Health and Social Care Information Systems and Technologies, CENTERIS /ProjMAN/ HCist*, pp. 431–438, 2017, doi:10.1016/j.procs.2017.11.058

[23] Aakhus M, Agerfalk P, and Lennmyr F. Digital Innovation as Design of Digital Practice: Doctors as Designers in Healthcare, *Proceedings of the 51st Hawaii International Conference on System Sciences*, pp. 4594–4601, 2018, doi:10.24251/HICSS.2018.579

[24] Desveaux L, Soobiah C, Bhatia RS, and Shaw J. Identifying and Overcoming Policy-Level Barriers to the Implementation of Digital Health Innovation: Qualitative Study, *Journal of Medical Internet Research*, vol. 21, no. 12, pp. 1–10, 2019, doi: 10.2196/14994.

[25] Hund A, Drechsler K, and Reibenspiess VA. The current state and future opportunities of digital innovation: A Literature review, *Association for Information Systems AIS Electronic Library (AISeL) ECIS 2019 Proceedings*, pp.1–15, 2019, [Online]. Available: https://core.ac.uk/download/pdf/301379523.pdf

[26] Mackey T, Kuo TT, Gummadi B, Clauson K, Church G, Grishin K, Barkovich R, and Palombini M. 'Fit-for-purpose?'-Challenges and opportunities for applications of blockchain technology in the future of healthcare, *BMC Medicine*, vol. 17, no. 68, pp.1–17, 2019, doi: 10.1186/s12916-1296-7

[27] Pundziene A, Heaton S, and Treece D. 5G, Dynamic Capabilities and Business Models Innovation in Healthcare Industry, *2019 IEEE International Symposium on Innovation and Entrepreneurship (TEMS-ISIE)*, pp. 1–8, 2019, doi:10.1109/TEMS-ISIE46312.2019.9074330

[28] Ricciardi W, Barros PP, Bourek A, Brouwer W, Kelsey T, and Lehtonen L. How to govern the digital transformation of health services, *European Journal of Public Health*, vol. 29, pp. 7–12, 2019, doi: 10.1093/eurpub/ckz165

[29] Aapro M, Dasari A, Bossi P, Fallowfield L, Gascon P, Geller M, Jordan K, Kim J, Martin K, and Porzig S. "Digital health for optimal supportive care in oncology: benefits, limits, and future perspectives", *Supportive Care in Cancer*, Vol 28, no. 2020, pp. 4589–4612, 2020, doi:10.1007/s00520-020-05539-1.

[30] Augustin DA, Yock CA, Wall J, Lucian L, Krummel T, Pietzsch JB, and Azaury DE. Stanford's Biodesign Innovation Program: Teaching opportunities of value-driven innovation in surgery, *Surgery*, vol. 167, no. 2020, pp. 535–539, 2020, doi: 10.1016/j.surg.2019.10.012.

[31] Barney A, Buckelew S, Mesheriakova V, and Flesch MR. The COVID-19 Pandemic and Rapid Implementation of Adolescent and Young Adult Telemedicine: Challenges and Opportunities for Innovation, *Journal of Adolescent Health*, vol. 67, no. 2020, pp.164–171, 2020, doi: 10.1016/jadohealth.2020.05.006.

[32] Condry MW, Quan XI, and Fiang M. Digital Health: Innovation, Opportunity, and Challenges, *IEEE Xplore*, pp. 3408–3412, 2020, doi: 10.1109/IECON43393.2020.9255276.

[33] Hein AE, Vrjens B, and Hiligsmann M. A Digital Innovation for the Personalised Management of Adherence: Analysis of Strengths, Weaknesses, Opportunities, And Threats, *Frontiers in Medical Technology*, vol. 2, no. 604183, pp. 1–15, 2020, doi: 10.3389/fmedt.2020.604183.

[34] Bazel M, Mohammed F, and Ahmed M. Blockchain Technology in Healthcare Big Data Management: Benefits, Applications and Challenges, *2021 1st International Conference on Emerging Smart Technologies and Applications (ESmarTA)*, pp. 1–8, 2021, doi: 10.1109/eSmarTA52612.2021.9515747.

[35] Condry MW and Quan XI. Digital Health Innovation, Informatics Opportunity, and Challenges, *IEEE Engineering Management Review*, vol. 49, no. 2, pp. 82–88, 2021, doi: 10.1109/EMR.2021.3054330.

[36] Lee SM and Lee D. Opportunities and challenges for contactless healthcare services in the post-COVID-19 Era, *Technological Forecasting*, vol. 167, no. 2021, pp.1–10, 2021, doi: 10.1016/j.techfore.2021.120712

[37] Lemmen C, Simic D, and Stock S. A Vision of Future Healthcare: Potential Opportunities and Risks of Systems Medicine from a Citizen and Patient Perspective- Results of a Qualitative Study, *International Journal of Environmental Research and Public Health*, vol. 18, no. 2021, pp.1–20, 2021, doi: 10.3390/ijerph18189

[38] Nandini KP and Seshikala G. Role of Embedded Computing Systems in Biomedical Applications- Opportunities and Challenges, *2021 IEEE International Conference on Distributed Computing, VLS, Electrical Circuits and Robotics (DISCOVER)*, pp.332–335, 2021, doi: 10.1109/DISCOVER52564.2021.9663646

[39] Sheikh A, Anderson M, Albala S, Casadei B, Franklin B, Richards M, Taylor D, Tibble H, and Mossialos E. Health information technology and digital innovation for national learning health and care systems, *Health Policy*, vol.3, no.2021, pp. 383–396, doi: 10.1016/S2589-7500(21)00005-4

[40] Walker DM. The Health Information Technology Special Issue: Innovation and Emerging Opportunities in Time of Crisis, *The American Journal of Managed Care*, vol. 27, no.1, pp.1–8, 2021, doi:10.37765/ajmc.2021.88570

[41] Javaid M, Haleem A, Singh RP, Rab S, Suman R, and Khan IH. Evolutionary trends in progressive cloud computing-based healthcare: Ideas, enablers, and barriers, *International Journal of Cognitive Computing in Engineering*, vol. 3, no. 2022, pp.124–135, 2022, doi: 10.1016/j.ijcce.2022.06.001

[42] Morais D, Pinto FG, Pires IM, Garcia N, and Gouveia AJ. The influence of cloud computing on the healthcare industry: a review of applications, opportunities, and challenges for the CIO, *International Workshop on Mobile4Medicine: Mobile Systems and Pervasive Computing for Personalised Medicine (M4Medicine)*, pp. 714–720, 2022, doi: 10.1016/j.procs.2022.07.106

[43] Saraswat D, Bhattacharya P, Verma PA, Prasad K, Tanwar S, Sharma G, Bokoro P, and Sharma R. Explainable AI for Healthcare 5.0: Opportunities and Challenges, *IEEE Access*, vol. 10, no. 2022, pp. 84486–84517, 2022, doi: 10.1109/ACCESS.2022.3197671

[44] Verma A, Bhattacharya P, Madhani N, Trivedi C, Bhushan B, Tanwar S, Sharma G, Bokoro P, and Sharma R. Blockchain for Industry 5.0: Vision Opportunities, Key Enablers, and Future Directions, *IEEE Access*, vol. 10, pp.69160–69199, 2022, doi:10.1109/ACCESS.2022.3186892

[45] Thirunavukarasu R, Doss GP, Gnanasambandan R, Gopikrishnan R, and Palanisamy V. Towards computational solutions for precision medicine based big data healthcare system using deep learning models: A review, *Computers in Biology and Medicine*, vol. 149, no. 2022, pp. 1–16, 2022, doi: 10.1016/j.compbiomed.2022.106020

[46] Rosa M, Faria C, Barbosa AM, Caravau H, Roa AF, and Rocha NF. A Fast Healthcare Interoperability Resources (FHIR) Implementation Integrating Complex Security Mechanisms, *Procedia Computer Science*, vol. 164, no. 2019, pp. 524–531, 2019, 10.1109/ICIoS53627.2021.9651762

[47] Grisot M, Hanseth O, and Thorseng A. Innovation Of, In, On Infrastructures: Articulating the Role of Architecture in Information Infrastructure Evolution, *Journal of the Association for Information Systems*, vol. 15, pp. 197–219, 2014, doi: 10.17705/1jais.00357.

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Appendixes :
Appendix Table 1: A summary of opportunities for digital innovation in healthcare

Appendix Table 1: A summary of opportunities for digital innovation in healthcare

A summary of opportunities for digital innovation in healthcare			
Themes	Grouping of concepts	Description and application in healthcare	Citations
Precision/ personalised medicine/ healthcare	Precision medicine	The opportunity that digital innovation brings in reinventing the future of healthcare by facilitating the use of patients' genetics, environment, and lifestyle to select, diagnose, or provide treatment that best works for them.	[23] [26] [37]
	Increased openness toward approaches to personalise treatments and development of supportive digital health solutions	The opportunity that digital innovation brings in addressing the high complexity of treatment and approaches to medications as well as the uniqueness of patients' characteristics to meet their health needs.	[33]
	Improved adherence to medications with a narrow therapeutic window	The opportunity that digital innovation provides healthcare practitioners in enforcing adherence behaviour in treatment while narrowing the therapeutic window which could expose patients to other possible disease-related consequences and adverse effects.	[33]
	Better coordination between various healthcare entities	The opportunity that digital innovation provides health practitioners to better understand the communities that they are serving and develop interventions and outreach efforts to improve access to care.	[21]
	Early symptom detection and data creation	The opportunity that digital innovation provides in the early detection of symptoms and data creation to aid in the analysis of community health situations including pandemics.	[20] [35] [37]
	Verifiability of healthcare prediction models/systems	The opportunity that digital innovation provides in interpreting and verifying complex medical data analytics to ensure that transparency and decision-making are not prone to any errors and doubts.	[14] [20] [27] [29]
	Remote monitoring of health and wellness data	The opportunity provided by digital innovation to facilitate real-time delivery of wellness and medical data. Some applications of digital technologies in healthcare enabled improved connectivity and data access in remote areas.	[41]
	Remote robotic surgery	The opportunity for digital innovation to enable remote delivery in areas without fixed infrastructure and requiring mobility. The application of digital innovation in healthcare provides improved latency, reliability of data, and security coverage.	[27] [41] [43]
	Increased productivity and standard of living in a society	The opportunity for digital innovation to improve the lives of patients by increasing the efficiency of healthcare outputs. This will further allow patients to receive faster service in the same amount of time.	[38]

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	Interactive and tailored health care service(s)	The opportunity presented by digital innovation is to provide healthcare practitioners with educational healthcare resources that are tailored to a patient's specific treatment or procedure needs.	[20]
	Smarter medication	The opportunity for digital innovation lies in introducing real-time medication management and linking it to a health monitoring system. The application of digital technologies in healthcare can facilitate improved connectivity and data coverage in remote areas, further enhancing access to health services.	[27]
	Optimisation for the use of medicines	The opportunity presented by digital innovation to facilitate the safe and effective use of medicine from a patient-centred perspective is crucial in ensuring that medical interventions, treatment, and procedures result in the best possible outcomes.	[33]
	Reduction in unplanned visits and hospitalisation	The opportunity that digital innovation offers to detect health issues early and address them with precision. This opportunity further reduces unplanned hospitalisations from patients.	[29]
	Increased patient well-being and health	The use of digital health technologies presents an opportunity for patients to meet their medical needs in a most engaging and user-centric way while saving costs.	[3] [18] [21]
	Reduction of medical errors	The opportunity provided by digital innovation to improve upon failures resulting from communication issues and limitations in accessing patients' records.	[42]
	Patient-centric identity	The opportunity presented by digital innovation is to empower patients with the right to consent to and choose how their data is used in exchange for health services or even compensation.	[26] [41]
	Improved healthcare operational procedures	The opportunity for digital innovation to expand beyond the boundaries of healthcare while improving clinical health practices.	[3] [25] [43]
Interoperability	Improved system-level interoperability	The opportunity presented by digital innovation facilitates alignment across organisational activities to provide the foundation upon which healthcare processes can built.	[22] [24] [40]
	Medical information sharing	The opportunity presented by digital innovation to facilitate the sharing of medical information in the most efficient manner possible.	
	Medical data aggregation	The opportunity that digital innovation provides to aggregate data from digital technologies can help manage the health of patients by observing treatment impacts and conducting remote evaluations. It can also provide alerts when certain medical conditions need to be addressed.	[47]
	Increased trust	The opportunity for digital innovation to enhance trust and safety in handling medical data is significant. The	

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		immutability of ledgers in blockchain technology can be utilised as an example to prevent tampering with medical data. This means that medical data transmitted during a transaction can remain unaltered and untampered with, making any unauthorised alteration of the data impossible.	[20] [26] [34] [44]
	Transparency	The potential for digital innovation to improve patient relationships by utilising distributed ledger technology that includes a consensus mechanism to verify medical records and transactions.	[34] [44]
Privacy and Security	Access control for data owners	The opportunity for digital innovation to facilitate data access through blockchain technology, allows data owners to grant, alter, and revoke permissions for accessing data. This may provide various levels or degrees of security access.	[18] [21] [26] [34]
	Accessing data quality and certifying data source	The potential impact of digital innovation on the creation, access, and transmission of critical health data to ensure the reliability of medical information.	[3] [18] [31] [34]
	Increased medical data security	The opportunity that digital innovation brings to safeguard medical data and facilitate compliance among healthcare organisations and stakeholders who use medical data.	[42]
	Data privacy and compliance	The opportunity provided by digital innovation to ensure that medical data and records are only accessible to the health practitioners who require them during critical situations. This also entails that medical data and health records are identified and classified according to specific criteria and that they can only be shared with authorised healthcare professionals.	[19] [20] [26] [43]
	Increased data protection and regulation	The opportunity presented by digital innovation is the seamless facilitation of strategies and processes to secure and protect medical data.	[39]
Improved decision-making process	Closer involvement in the decision-making process	The opportunity for digital innovation to involve patients in expressing their opinions about different treatment methods, sharing information, and accepting healthcare instructions or recommendations.	[29]
	Increased cooperation between more heterogeneous contributors	The opportunity presented by digital innovation is the convergence of various areas of expertise, resulting in more distributed forms of cooperation in healthcare.	[25]
	Improved convergence of health processes and outcomes due to more flexibility	The opportunity that digital innovation provides is the use of digital health technologies to enable more open design spaces, faster cycle times, instant releases and updates of medical data, and universal design patterns.	[25] [29] [33]

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	Improved new forms of measuring success	Digital innovation presents an opportunity to measure the value of healthcare digital offerings, overcoming the limitations of monetary-based measurements.	[21] [25]
	Improved collaboration and communication among various stakeholders	Digital innovation in healthcare provides an opportunity for practitioners to assume complementary roles, work collaboratively, share responsibilities for problem-solving, and make decisions to conduct plans for patient care.	[21] [25] [36] [41]
	Better coordination between various healthcare entities	The opportunity that digital innovation provides for health practitioners to better understand the communities they serve. This further helps in developing interventions and outreach efforts to enhance access to healthcare.	[21]
Real-time/remote monitoring	Real-time patient monitoring	The opportunity for health practitioners to utilise digital innovation to predict, analyse, and evaluate medical data in real-time. This service offers precise interpretation or conversion of medical data to ensure it is aligned with the appropriate treatment and decision-making processes.	[21] [28] [29] [36] [39] [43]
	Condition Tracking	The management of pandemics can benefit greatly from digital innovation, which allows for the use of standardised medical data and the collection of data from various sources. This data can later be queried to create profiles of patients who have been tested.	[35] [20]
	Remote monitoring of health and wellness data	The opportunity for digital innovation in healthcare is immense, as it can facilitate the real-time delivery of wellness and medical data. Some applications of digital technologies in healthcare allow for increased mobility and scalability.	[14] [20] [27] [41]
	Medical asset tracking and management	The opportunity for digital innovation to facilitate the automation of supply management and increase effectiveness. The application of digital innovation in healthcare includes increased connectivity, improved location accuracy using drones, and expanded connectivity and data access for outdoor procedures.	[27] [41]
	Remote robotic surgery	The opportunity for digital innovation to enable remote delivery in areas without fixed infrastructure and requiring mobility. The application of digital innovation in healthcare provides improved speed, reliability of data, and enhanced security.	[27] [41]
	Improved healthcare operational procedures	The opportunity for digital innovation to expand beyond the boundaries of healthcare while improving clinical health practices is significant.	[3] [25] [43]
	Maintain the patient's	The opportunity provided by digital innovation allows for patients' medical information to be utilised across	[3] [25]

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Enabling new processes, services, and products	functional capacity and health	organisational and regional boundaries, where applicable.	
	Increase in medical data processing capacity	The opportunity presented by digital innovation to facilitate the collection, aggregation, cleaning, and updating of medical data is invaluable in informing strategic decisions related to medical treatments, interventions, and procedures.	[12] [14]
	Improved health processes	Digital innovation provides health practitioners with the opportunity to utilise health outputs, advanced health analytics tools, and insights to develop successful strategies that consistently aim for better outcomes, improved patient experience, and reduced costs.	[12]
	Creation of new business models and value propositions	The opportunity that digital innovation brings to healthcare is the ability to employ digital technologies to redesign healthcare business models that benefit healthcare organisations.	[12] [25] [28]
	Enabling outsourcing and offshoring of medical tasks and services	The opportunity for digital innovation in healthcare includes the ability to collaborate with third-party organisations that specialise in specific areas of digital health technology to perform particular functions or tasks. These digital health technology needs could be outsourced to another country.	[12]
	Automation of healthcare processes	The opportunity that digital innovation brings is to facilitate the modernisation of healthcare processes, making them more dynamic and responsive. This can improve patient satisfaction and the overall patient experience in a variety of ways.	[26]
	Integration of electronic health records across health and care providers	The potential of digital innovation to provide a more consistent and comprehensive approach to healthcare, including care and support, requires prioritising the delivery of health services through a cohesive set of methods, funding, administrative, organisational, and clinical levels that foster connectivity, alignment, and collaboration among various healthcare entities.	[26]
	Optimisation for the use of medicines	The opportunity presented by digital innovation to facilitate the safe and effective use of medicine from a patient-centred perspective is crucial in ensuring that medical interventions, treatments, and procedures yield the best possible outcomes.	[33]
	Decentralisation	As opposed to centralised access, where medical data storage is fragmented, digital innovation can decentralise access and increase transparency with affordable processing power by utilising blockchain technology in healthcare. This can make healthcare systems more robust and effective.	[34] [41] [44]
	Improved service structures that ensure long-term sustainability and patient-centeredness	Digital innovation provides an opportunity to empower patients with low health literacy and move them away from being passive. Digital innovation helps individuals become more responsible and capable of self-managing their medications.	[33]
	Improved efficiency and	The opportunity presented by digital innovation is to facilitate the allocation of available health resources to	[3]

	appropriateness of care and safety	where they are needed the most, while simultaneously improving the quality of healthcare services.	
	Change in services, products, experiences, and business ecosystem	The opportunity for digital innovation to facilitate new capabilities in designing business models and leveraging healthcare resources to meet patients' expectations and capture value.	[27]
Training/ Education	Building stakeholders' confidence	The opportunity that digital innovation brings is to equip stakeholders with basic knowledge to establish how decisions are made and to better understand the decision support system in healthcare.	[43]
	Smarter education and training	The potential of digital Innovation to enhance remote and augmented reality training for medical procedures. The application of digital innovation in healthcare includes improvements in latency, reliability, data throughput, extended coverage, and security.	[27]
Knowledge Acquisition/ sharing	Knowledge acquisition and knowledge sharing	The opportunity provided by digital innovation allows healthcare professionals to acquire and share new knowledge, ensuring that common goals are achieved effectively. The new generation of digital health technologies requires exposure to new knowledge acquisition to better support healthcare initiatives driven by digital innovation.	[8] [27] [43]
Additional themes	Cost-saving and effectiveness	The opportunity for digital innovation to facilitate the reduction of costs and time consumption, as well as the high risk of fraud and duplication of medical data and products, can be achieved through a more decentralised medical database system.	[1] [3] 18] [21] [28] [29] [30] [44]
	Manage human health	The opportunity that digital innovation brings is to test symptoms and take appropriate or corrective medical measures.	[32] [35]
	Effective time-management	Digital innovation offers health practitioners the opportunity to intelligently organise their time, manage tasks and processes with greater productivity, and improve the quality of their work.	[29] [41]
	Timesaving in the analyses of patients' data	Digital innovation presents an opportunity to reduce the time required for analysing patients' data and providing recommendations for appropriate treatments.	[29] [41]
	Reduced burden and anxiety	The opportunity for digital innovation to reduce the risks of a wide array of diseases and complications that may worsen patients' health conditions.	[29]

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An analysis of nurses' lived experience with digital health technologies in practice

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Background and Purpose: In the healthcare field, technological innovations have been introduced which are referred to as digital health technologies (DHTs). As digital technologies continue to impact the nursing profession on a global scale, nurses are increasingly required to use a variety of digital health technologies when providing direct care across the healthcare sphere. Whilst the benefits of DHTs have been empirically proven, usability problems, often encountered with usage, can be frustrating to both healthcare professionals and patients compared to other industries. The aim of this qualitative study was to understand, analyse and assess nurses' lived experiences of using DHTs as part of their work practices.
Methods: The study employed an interpretive stance and a qualitative phenomenological approach to explore the lived experiences of experienced nurses presently using DHTs in practice. In-depth interviews and observation were used to collect data from nurses in two public hospitals in Cape Town. A thematic analysis was used to organise and analyse the data acquired from the participants. The Normalization Process Theory (NPT) served as a theoretical lens to interpret the findings of this study. Purposive sampling was used to identify participants.
Results: Nurses, as end-users, have found DHTs to be relevant to their work practices and compatible with their existing work practices. It was found that, through the use of technology, nurses' tasks have become easier and more time-efficient, and as a result, nursing quality is improved.
Conclusions: Findings indicate that DHTs have been fully embedded into their daily work activities as patient care is optimised. Nurses positively appreciate technologies, to the extent that they cannot do their work without DHTs, and this is substantiated by their desire to learn new technology, not only to optimise patient care but to augment their knowledge and skill.

Keywords: nurse, digital health, digital health technology, lived experience, normalisation process theory.

1 Introduction

In the healthcare field, technological innovations have been introduced, which are referred to as digital health technologies (DHTs). As digital technologies continue to impact the nursing profession on a global scale, nurses are increasingly required to use various digital health technologies when providing direct care across the healthcare sphere. Several information and communication technology (ICT) systems are used in healthcare organisations to serve physicians and other healthcare professionals in their daily work with patient treatment services. These systems describe a broad range of applications, from the widely used computerised physician order entry (CPOE) systems to modern speech recognition technologies and mobile applications, diagnostic and imaging, clinician decision support and electronic prescribing technologies, a variety of patient monitoring systems using sensor network technology, and electronic health records (EHR) [1] [2] [3].

Digital health, or the use of digital technologies for health, has become a prominent field of practice when it comes to employing routine and innovative forms of information and communications technology (ICT) to address health needs. Rooted in e-Health, the term digital health is defined as "the use of information and communications technology in support of health and health-related fields" [4]. Mobile health

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(mHealth), a subset of eHealth, is defined as "the use of mobile wireless technologies for health" [4]). More recently, the term digital health was introduced as "a broad umbrella term encompassing eHealth (which includes mHealth), as well as emerging areas, such as the use of advanced computing sciences in 'big data', genomics and artificial intelligence" [4].

Studies have shown that implemented digital health technologies (DHTs) are essential, and the general consensus within and across the scientific research space is that they have the potential to improve patient safety and quality of care and reduce the cost of healthcare [5] [6] [7] [8]. Although the benefits of DHTs have been empirically proven, usability problems, often encountered with usage, can be frustrating to both healthcare professionals and patients compared to other industries [9] [10][11]. A number of challenges seem to recurrently hamper the effective use of DHTs, especially in the context of this study – Cape Town, South Africa. The implementation and use of DHTs have particularly been below par given that an e-Health strategy has been developed since 2012.

Furthermore, as the proliferation of ICTs has taken over healthcare organisations globally, information sharing and retrieval have become easier, with greater reliance on computers. A number of studies indicate that nurses, therefore, are not exempted from learning and using technology, and easy and quick access to information is crucial for effective nursing today [12] [13] [14] [15]. An important aspect of nursing and the nursing process is the management of patient information since the timeous exchange of relevant information of a patient is essential to ensure quality of care. Critical patient information is conveyed in a variety of forms, for example, through the DHTs such as the electronic health record, healthcare decision support systems, referral co-ordination, prescription and medication management, laboratory and diagnosis management.

Because the nursing profession has been influenced by the influx of DHTs, research indicates that nursing and technology are inextricably linked [16]. Healthcare in intensive care settings is more complex, as DHTs like ventilators, infusion pumps, monitors, and dialysis machines need to be carefully managed. *Technology* is regarded as items, machinery and equipment which are connected to knowledge and management to maximise efficiency. The authors further reiterate that it is not just the equipment per se, but rather, knowing how to use it and being able to integrate it into nursing care [10].

In most hospitals, intensive care units (ICUs) in particular, are highly technological environments. Patients in ICUs require specific technical nursing activities, such as attaching patients to life support equipment, and 24-hour supporting, treating and monitoring of patients' vital signs. Whilst attending to these activities, nurses are also required to attend to the physical as well as psychosocial needs of patients and their families [17]. It is therefore imperative for nurses to have the required technical skills as it forms an integral part of the caring process. Technology in an ICU also includes the use of medical-technical equipment. *Medical-technical equipment* refers to "equipment that will detect, prevent, monitor, treat, compensate for injury and disability or alleviate disease" [10]. Nurses working in ICUs, therefore, perform much of their work through the use of medical-technical equipment.

From the aforementioned, it is clear that, as proficiency in the use of DHTs is essential in today's nursing care, the advantages of using DHTs in the nursing profession are limitless. It is therefore imperative for nurses to improve their competencies [18] [19] [20] [21]. Nurses must continuously utilise technology as a means to access and manage records and to provide care via electronic means such as e-medicine and telehealth platforms. These digital technologies offer a significant opportunity to improve, enhance and transform healthcare [20]. However, to take advantage of these opportunities, nurses need to be competent; in other words, they need to possess the requisite knowledge, skills and resources to use technology and integrate it into their daily working activities.

Thus, due to the increasing use of technology in the healthcare sector, there is a growing need for nurses to incorporate the use of DHTs into their routine clinical work processes. Hence, nurses' acceptance of DHTs and their lived experiences play a significant role in public healthcare institutions. However, scientific research that adequately explores lived experiences of nurses using DHTs is limited, especially in the context of this investigation – Cape Town, South Africa. It is vitally important that policymakers, administrators and managers work together with nurses to ensure that access to technologies which support

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good practice, as well as the work activities of nurses, is not compromised by practices that do not take into consideration the needs of nurses and their patients [18]. Moreover, a lack of inclusion of nurses not only negatively impacts the quality of care that patients receive, but also the overall efficiency of the healthcare system [22] [23][24]. Therefore, failure to include nurses in the design and development of new technologies will not only negatively impact the quality of care that patients receive, but also impacts the morale of nurses.

1.1 Problem statement

When considering the lived experiences of using DHTs in practice, the perspectives of nurses have received insufficient attention [18] [25][26]. Consequently, the literature suggests that there is limited information on the experiences of nurses regarding the use of DHTs in healthcare in sub-Saharan Africa (including South Africa) to guide future use thereof, particularly in view of the current influx of ICT into the region [27] [28]. With little or no information with regards to acceptability and usability of DHTs from nurses (the dominant group of end-users in a clinical setting), research is needed to begin to fill this gap in knowledge. It can thus be argued that, owing to the increasing use of technology in the healthcare sector, there is a growing need for nurses to incorporate the use of DHTs into their routine clinical work processes. Whilst the literature supports that these technologies have great benefits, the impact on nurses and their workflow is not well known.

1.2 The objective of the research paper is the following

To ascertain how nurses make sense of the work practices as DHTs influence their daily work activities, and to accomplish the objective of this research paper, the study sought to answer the following research question and sub-questions:

Research Question:
How do nurses experience their work practices influenced by DHTs?

This question is based on the lived experience of the nurse who uses DHTs in the nursing care process when providing care to patients in a particular situation.

Sub-questions:
How are DHTs incorporated into nurses' work activities?
For what purposes are DHTs used by nurses?
What are the perceptions and experiences of nurses in the use of DHTs?

2 Research Methodology

Research Design: Since this research project was aimed at studying social actors (nurses and administrators) in their natural environment and focused on understanding the world from their point of view, the researcher has adopted an interpretive stance. The study sought to draw from the concepts of the normalisation process theory (NPT) as a theoretical lens to analyse how new technological innovation can be embedded into existing routine nursing practices rather than build a new theory. With this research study being qualitative in nature, interpretative phenomenology was an ideal methodology to use, mainly since this study focused on how individuals make sense of their DHTs used as part of their daily work activities. This interpretive phenomenological approach has helped to achieve the aim of this study and to answer the research question and sub-questions.

An interpretive study of nurses as end-users of DHTs has thus yielded important information about barriers, frustrations, needs, and preferences of nursing staff. Interpretive research with qualitative interviews was considered to be the most appropriate starting point, as it has provided access to nurses' subjective perceptions of DHTs. The data gained from the study was also valuable in determining nurse users' specific needs and their preferences for modifications to the DHTs being used.

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The sampling method used: the researcher used non-probability sampling via purposeful sampling to identify and select end-users who use DHTs as part of their daily work activities. This technique assisted the researcher in identifying a sample size that would provide in-depth information which is aligned with the research objectives of this study. A purposive sampling strategy is most commonly used in phenomenological research because it allows the researcher to select participants with rich knowledge of the phenomenon and is thus appropriate for an interpretive phenomenological study [26] [29].

Inclusion criteria for the participants: All ethical considerations were observed throughout the course of this research project. Ethical clearance was obtained from the Institution's Faculty of Health and Wellness Ethics Committee, as well as from the Faculty of Informatics and Design Ethics Committee. Thereafter, permissions were obtained from the Western Cape Department of Health to conduct the research within the selected tertiary and district hospitals. Participants' views were respected, and participants were given an option not to respond if they so choose. All personal data of participants gathered during the research, as well as their responses, were treated as confidential. It was made clear to participants that they were under no obligation to participate and may choose to withdraw from the study or refuse to answer any questions of any type, without suffering any consequences.

Two hospitals (one tertiary hospital and one district hospital) in the Western Cape were earmarked for selecting participants and data collection. A total of 22 participants (14 from Hospital A and 8 from Hospital B) were purposefully selected and interviewed until saturation was reached. A variety of criteria was applied during the selection of participants, including the level of education, role, profession, job position/rank, work experience and station. Moreover, participants were selected according to age (>18 years) and the number of years of experience as a registered nurse The age distribution of this category of participants ranged between 31-60 years, with 50% falling in the 31-40 age bracket, while 41-50 and 51-60 groups constituted 25% each. At Hospital A, a total of 14 participants responded positively, indicating a willingness to participate. The participants interviewed comprised four nurses and two nurse managers from the General ICU, six nurses from ICU and two nurse managers from the Cardiac ICU. At Hospital B, seven nurses and the operations manager of the Emergency Unit were interviewed. The researcher specifically chose to investigate the work activities of registered nurses and nurse managers who actively use technology as part of their daily work activities.

Data Collection: The major data collection methods associated with an interpretive phenomenological study were in-depth interviews and observation. The sources of data collection comprised two categories, namely secondary data (the literature review) and primary data (from interviews with participants engaged in the delivery of healthcare). The interviews enabled the researcher to obtain a large volume of subjective data, which was then interpreted to gain in-depth information as understood and interpreted from the participants' points of view. In addition to interviews, observation was used to supplement the primary data gathered from interviews.

Observation forms were designed and relied on to capture events unfolding before the interviews. This assisted the researcher in taking field notes whilst observing participants in their environments during the study. The researcher could clearly observe participants, which assisted in gaining deeper insights into the phenomenon being studied. The researcher was able to observe the interactions between the various stakeholders, as well as the types of DHTs that were being used.

The interview instrument was developed based on a review of the literature, the research questions and also the normalisation process theory (NPT) as a guideline. During the interview sessions at both hospitals, the researcher endeavoured to refrain from asking leading questions and, instead, allowed the participants to narrate their experiences freely. During the interview, follow-up questions were posed. For example, the researcher would ask: Could you give me an example? How or what do you mean? Could you explain in a bit more detail? How did you feel about that? Can you describe that in more detail? The interviews were characterised by openness and flexibility, and the results of this study can attest to the fruitfulness of a descriptive method. Interviews were digitally recorded and transcribed verbatim by the researcher. Each interview was transcribed, compared with written notes and observations, and then saved, and participants

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were anonymised by being assigned a particular code. Each transcript was saved under this unique code. Participants were given the opportunity to review transcripts of the interview to clarify, revise or delete any portions thereof if they wished to do so.

Data Analysis: Two types of data analysis were performed for this study, namely a theoretical analysis using the Normalisation Process Theory (NPT) as an analytical lens and a thematic analysis of the data collected. The NPT has played a significant role in this qualitative research project as it has assisted in the research design, sampling and data collection. Furthermore, it has helped to inform, guide and structure the research focus and questions. Each construct was used to answer the main research questions and interpret the subsequent findings of this study. The normalisation process theory (NPT) served as a theoretical lens to interpret the findings of this research project, as it provided a conceptual framework that served to explain the processes whereby new health technologies and other complex interventions can be routinely embedded (operationalised) into everyday work, and integrated (sustained) in practice. Furthermore, it has served to elaborate on how new technological innovation can be embedded into existing practices – in line with the research problem of this study. Each recorded interview was transcribed verbatim, and the researcher spent much time reading and re-reading each transcript carefully.

The second analysis of the qualitative data obtained through interviews and observations, which include perceptions, attitudes, beliefs and opinions of participants regarding the phenomenon of this study, was undertaken using a thematic analysis. The semi-structured interviews were recorded, and the researcher listened and re-listened intensely to the recordings of the interviews, whereafter, recorded interviews were transcribed from audio to verbatim text. The researcher then examined the raw textual data line by line in an attempt to identify distinct events, incidents, ideas, actions, perceptions and interactions of relevance that are coded as concepts. A coding process was applied whereby the words or phrases were assigned descriptive codes. The researcher made use of descriptive codes to tag the emerging attributes, viz., keywords or phrases, as it relates to the issue that is being investigated and, thereafter, to categorise the themes. From the coding process, ten major themes emerged: 1) decision-making, 2) adapting to change, 3) DHT use, 4) DHT access, 5) DHT development, 6) information, 7) nursing administration, 8) patient care, 9) training and 10) workarounds.

3 Results

The NPT has played a significant role in this qualitative research project as it has assisted in the research design, sampling and data collection. Furthermore, it has helped to inform, guide and structure the research focus and questions. Each construct, namely, Coherence, Cognitive Participation, Collective Action and Reflexive Monitoring, was used to answer the main research questions and interpret the subsequent findings. It was essential to have a good comprehension of the NPT constructs to use them when analysing the data. Each core construct was interpreted in terms of the explanation of its associated NPT constructs. After the explanations) for the core NPT were interpreted, the NPT constructs were mapped to the interview questions (IQ), and explanations were formulated [30]. The table below summarises the results of the NPT analysis.

Table 1: Key findings of NPT analysis

COHERENCE is the sense-making work that people do individually and collectively when they are faced with the problem of operationalising some set of practices. [Sub-constructs: differentiation, communal specification, individual specification and internalisation.]
Key finding: Participants have a sense of purpose; they have a deep understanding of the DHTs how they fit into their overall goals and activities, and how these technologies impact their work practices.

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COGNITIVE PARTICIPATION is the relational work that people do to build and sustain a community of practice around a new technology or complex intervention. [Sub-constructs: initiation, enrolment, legitimisation and activation.] **Key finding: There appears to be buy-in from participants to the extent that participants feel the need to invest time and energy into learning new technologies. However, a number of barriers were uncovered which hamper participants' ability to sustain their involvement in the use of DHTs**
COLLECTIVE ACTION is the operational work that people do to enact a set of practices, whether these represent a new technology or complex healthcare intervention. [Sub-constructs: interactional workability, relational integration, skill set workability and contextual integration.] **Key finding: Participants have expressed confidence in the system and positively appreciate technology. The many benefits derived from DHTs enhance patient care and facilitate access to and the management of information. Overall, technology makes their work easier.**
REFLEXIVE MONITORING is the appraisal work that people do to assess and understand the ways that a new set of practices affect them and others around them. [Sub-constructs: systemisation, communal appraisal, individual appraisal and reconfiguration.] **Key finding: Participants are receptive to the use of DHTs and do not see it as a barrier between them and their patients. However, concern was expressed at the non-inclusion of nurses in the design and development of DHTs, and the fact that there is no channel for nurses to appraise the DHTs used as part of their daily work practices.**

Furthermore, an analysis of the qualitative data obtained through interviews and observations, and which include perceptions, attitudes, beliefs and opinions of participants regarding the phenomenon of this study, was undertaken by means of a thematic analysis. From the coding process, ten themes emerged, namely: 1) decision-making, 2) adapting to change, 3) DHT use, 4) DHT access, 5) DHT development, 6) information, 7) nursing administration, 8) patient care, 9) training, and 10) workarounds. The themes of this study emerged from the interviews conducted with 22 participants (17 registered nurses, four nurse managers and one operations manager) regarding the use of DHTs as part of their daily work activities. These individuals willingly shared their valuable time and experience with the researcher during their interviews and observation sessions. The accounts of their experiences were an integral and essential part of this research project to gain a deeper understanding of their lived experience with DHTs (refer to Table 2 below).

Table 2: Key findings of thematic analysis

Decision-making	Nurses often use their knowledge, intuition and experience to make decisions based on their awareness of a particular situation. Therefore, given the nature of the DHTs available to nurses in an ICU and EC setting, these technologies facilitate nurses in their decision-making and optimises patient care.
Adapting to change	Reactions reflected a high degree of awareness of the immense benefits of DHTs and how it optimises the work practices of participants. Whilst there was initial resistance, predominantly due to fear of the unknown, many fears have been allayed once participants came to appreciate the value of DHTs.
DHT use	Participants have stated that DNTs do not hinder the nurse-patient relationship. Whilst there is consensus on the benefits of using DHTs as part of their work activities, participants have expressed concrete ideas on how to further optimize their work practices through the use of DHTs, for example, having their own login credentials to look up patients' results, having their own email addresses, and having an opportunity to provide feedback on DHTs that are currently being used. It was noted that very few nurses have their own login credentials.

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DHT access	The participants notably highlighted the following barriers that hampered their DHT use and access: insufficient number of computers, the limited time assigned to the triage process, a lack of login credentials, limited training opportunities, the long response time when technologies need repair, poor connectivity, occasional patient resistance to the use of technology, and the (sometimes negative) effect of DHTs on the nurse-patient relationship, and the need for electronic reporting as opposed to manual reporting.
DHT development & support	Whilst the importance and relevance of nurses' participation in the process of technology development are`` frequently stressed by developers, scientists and funding bodies, their actual participation has been described as negligible. Furthermore, nurses often fail to identify and communicate their needs and ideas for application scenarios or improvements to DHT in everyday care practice. Responses were gathered from nurse managers at Hospital A and the Operations Manager at Hospital B. As end-users of DHTs, it is imperative that nurses be included in the process of developing new technologies.
Information	The results indicate unanimous agreement amongst participants that technology has become an integral part of patient care, particularly in the ICU, because it saves time, it facilitates the monitoring of patients, improves patient administration and access to patient information. Some of the benefits of information availability are: improved recordkeeping, easy access to and flow of information, improved productivity as DHTs reduce time spent with patients.
Nursing administration	Since DHTs are incorporated into the daily work activities of nurses, there is notable improvement in nursing administration, as well as recordkeeping. Nursing administration is optimised because doctors, nurses and clerks have access to the system.
Patient care	The positive impact of technology, particularly where the technology improved nurse-patient interaction, is evident from the participants' responses. The use of technological devices provides convenience, particularly cardiac monitors have positive benefits by monitoring the patient's vital signs continuously and transmitting data in real-time as well as remote monitoring.
Training	Nurses have overwhelmingly indicated that their training needs were not assessed prior to the introduction of any new technology. Whilst nurses positively appreciate technology, the lack of training is a significant barrier that seems to hinder their ability to derive maximum benefit and pass such benefit on to their patients. Training is in the form of peer-to-peer or learning-by-doing, which is not ideal. Concerning the organisation of training programmes, the results showed they are organised at a moderate frequency; however, nurses are not keen to capitalise on it due to their situated practice. There are often staff shortages, which deters them from attending formal training programmes. Participants also cited a lack of time, family obligations, and lack of support from both the workplace and managers.
Workarounds	It is clear from the data that technology has made work easier and improved workflow and productivity. Nurses see technologies such as ventilators and cardiac monitors as a means of communication and guide them to what the needs of the patients are. Nurses feel that technology has a positive impact on the nurse-patient relationship, and whilst they are in agreement that technology does not negatively affect the nurse-patient relationship, they nevertheless do not fully trust technology and, as a result, have experienced technical problems with some of the DHTs. This has led them to resort to initiating workarounds to provide the best care for their patients. This means that, where necessary, nurses would resort to their foundational practices, for example, physically taking a patient's blood pressure or physically looking at the clinical picture of the patient instead of accepting the outcome of the cardiac monitor.

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When answering the research question and sub-questions, the results are presented in Table 3 below.

In an effort to determine how DHTs are incorporated into nurses' work activities, it was found that, as the end-user using digital health technologies in practice in the situational context of work, nurses have found DHTs to be relevant to their work and compatible with their existing work practices. This is evident from the results as it fits into their existing roles and skills, thereby enabling them to provide better care and service to their patients. Similarly, findings show that technology has become an integral part of patient care. From this, it is evident that DHTs have been fully incorporated into their daily work activities as patient care is enhanced.

> *"It is very relevant for us and very accurate because it can give you the time of arrival of the patient, the time awaited in triage. What time the patient was triaged, what time the patient was seen by the doctor and the waiting period of the patient is captured. When the patient is discharged, it also shows that the patient was in EC and now he or she is discharged. If the patient goes to another ward or an overnight ward, it also tells you that this patient is no longer in EC but has moved to another ward. It is very accurate." (Participant MP03)*

In an effort to determine the purpose for which nurses use DHTs, it was found that nurses have a highly positive appreciation for the DHTs used as part of their daily work practices because these technologies enhance decision-making and provide critical information to enable them to prioritise patient care.

> *It can accurately predict the severity of the patient's condition. Sometimes as nurses you can't always tell how sick the patient is. However, with this technology, if a patient is rated orange, it can tell you that the patient has chest pain and you can immediately do an ECG. (Participant MP02)*

The use of DHTs as part of nurses' daily work activities has drastically improved patient care. With technology, nurses' tasks have become easier and more time-efficient, and nursing quality has improved.

> *"So we stand in one place and can observe over 20 patients' vital signs at once and act immediately when there is a problem." (Participant TB01)*
> *"The service delivery is quicker, and the waiting time is shorter. I can also see on the doctor's computer because we are linked." (Participant MP05)*

When determining the perceptions and experiences of nurses in the use of DHTs, the findings indicate that DHTs have been fully incorporated into their daily work activities as patient care is optimised. Nurses, as end-users, have found DHTs to be relevant to their work practices and compatible with their existing work practices. It was found that, through the use of technology, nurses' tasks have become easier and more time-efficient, and as a result, nursing quality is improved.

> *We don't have to write as before, you enter electronically. Sometimes papers get lost or misplaced, then you have to rewrite it. However, it is on the system, it improves productivity. It used to take 15 minutes to triage a patient, but now it is easy and takes less time. (Participant MP03)*

Nurses positively appreciate the DHTs; this is evident in their desire to learn new technology, not only to optimise patient care but to augment their knowledge and skill. The findings further indicate positive perceptions from nurses to the extent that they cannot do their work without DHTs; as noted above, this is substantiated by their desire to learn new technology, not only to optimise patient care but to expand their knowledge and skill.

> *I would love to learn new technology. I need to know the patient's results. I often order x-rays, and I interpret the x-rays and blood results, and sometimes you need proper training. (Participant MP03)*

Table 3: Research Question 1 answered.

Research Question 1 (RQ1): **How do nurses experience their work practices influenced by DHTs. This question is based on the lived experience of the nurse who uses DHT in the nursing care process when providing care to patients in a particular situation.**	
Sub-Questions	**Objective**
RSQ1: How are DHTs incorporated into nurses' work activities	To determine how DHTs influence nurses' work activities.
RSQ2: For what purposes are DHTs used by nurses?	To ascertain why nurses use DHTs.
RSQ3: What are the perceptions and experiences of nurses in the use of DHTs?	To determine how nurses perceive and experience the use of DHTs in practice.
RESEARCH QUESTION 1 ANSWERED: *The findings indicate that DHTs have been fully incorporated/embedded into their daily work activities as patient care is optimised. As end users, nurses have found DHTs relevant to their work practices and compatible with their existing work practices. It was found that, through the use of technology, the nurses' tasks have become easier and more time-efficient, and, as a result, nursing quality is improved. Nurses positively appreciate the DHTs, and this is evident in their desire to learn new technology, not only to optimise patient care but to augment their knowledge and skill. The findings further indicate positive perceptions from nurses to the extent that they cannot do their work without DHTs. This is substantiated by their desire to learn new technology, not only to optimize patient care but to augment their knowledge and skill.*	

4 Discussion on results

Analysing the data by firstly using the NPT as an analytical lens and secondly by means of a thematic analysis has afforded the researcher a deep understanding and insight of and into the lived experiences of nurses as they experience DHTs as part of their daily work activities.

The evidence overwhelmingly suggests that DHTs have permeated nurses' lives and, as such, have become embedded into their everyday lives. It is further evident that nurses' work activities are still largely paper-based with a combination of support provided by various digital health technologies. Whilst clinical notes and observations are largely paper-based (and later scanned), electronic systems are used to monitor patients, perform triage, register patients electronically, and perform a variety of administrative duties.

Analysing the data using the NPT as an analytical lens and by means of a thematic analysis has afforded the researcher a deep understanding of the lived experience of nurses as they experience and use DHTs as part of their daily work activities.

The ten themes which emanated from the analysis are a representation of the many ways whereby DHTs facilitate nurses' jobs. Whilst there is consensus that technology is positively received by participants and that the benefits are immense, a number of barriers have been identified that prevent participants from deriving maximum benefits from the DHTs being used. These barriers include nurses not having their own login credentials to look up patients' results, an insufficient number of computers, a lack of training, etc. Furthermore, this is exacerbated by the lack of inclusion of nurses in the development and implementation of new technologies.

When combining the results of the ten themes of the thematic analysis while also mapping it to the results derived from the NPT analysis, a number of conclusions can be drawn. Although similarities were considered, the mapping of each NPT sub-construct was not necessarily aligned with the data themes because the focus of this study was not on verifying the NPT theory but rather on using it as an additional theoretical lens during the analysis of the data.

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The first consideration was whether any findings from the NPT analysis do not have a similar finding from the thematic analysis. It is important to note that when the researcher analysed the data through the lens of the NPT, all four constructs, including sub-constructs, were used. Interestingly, whilst the researcher was investigating the applicability of the NPT in similar studies, the researcher found that most studies only used one construct, for example, Collective Action [31] [32].

When mapping the findings of the NPT to the thematic analysis, an important finding is that whilst the NPT serves as a conceptual framework to explain the processes whereby new health technologies and other complex interventions can be routinely embedded or operationalised into everyday work and subsequently sustained in practice, the NPT constructs only focus on the implementation of new health technologies and not on the design and development thereof. The NPT, therefore, does not make provision for the design and development of complex interventions. A possible reason could be that the framework was designed to be used from an end-user perspective and not from the perspective of the developer.

The next consideration is whether there are findings from the thematic analysis that were not present from the NPT analysis (refer to Table 2). The theme of decision-making, when mapped to the constructs of the NPT, could only be linked to the construct, Collective Action. This construct served to ascertain whether DHTs promote or impede the work of nurses, whether it is compatible with work practices and the impact thereof on the division of labour. In particular, it relates to the sub-construct of skill set workability, which refers to the degree to which the technology fits into existing work practices, skill sets and the nurses' perceived work role. Furthermore, it enhances their existing roles and skills, thereby enabling them to provide better care and service to their patients. However, the construct does not explicitly focus on the decision-making aspect of nurses' jobs.

The next consideration is to determine which findings from both the thematic and NPT analysis are similar. The theme, DHT use, could be mapped to all four NPT constructs. This is significant because key findings from the data indicate that there is consensus amongst the participants regarding the benefits of using DHTs as part of nurses' daily work activities. Furthermore, since DHTs have become an integral part of their lives, and many nurses have become very skilled in the use of DHTs, they have expressed concrete ideas on how some DHTs could be adapted to optimise their work. From this, the researcher can deduce that DHTs have been embedded into the work practices of nurses. This is also a clear indication that DHT could be further optimised if nurses' input were to be considered prior to the implementation thereof.

In an effort to ascertain how nurses make sense of the work practices as DHTs influence their daily work activities, the findings indicate that DHTs have been fully incorporated into their daily work activities as patient care is optimised. Nurses, as end-users, have found DHTs to be relevant to their work practices and compatible with their existing work practices. It can thus be concluded that, through the use of technology, nurses' tasks have become easier and more time-efficient, and as a result, nursing quality is improved. Nurses positively appreciate the DHTs; this is evident in their desire to learn new technology, not only to optimise patient care but to augment their knowledge and skill. Despite a number of barriers, the findings further indicate positive perceptions from nurses to the extent that they cannot do their work without DHTs; as noted above, this is substantiated by their desire to learn new technology, not only to optimise patient care but to enhance their knowledge and skill.

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Statement on conflicts of interest
None

References

[1] Ahlan, A. and Ahmad, B. 2015. An overview of patient acceptance of health information technology in developing countries: A review and conceptual model. *International Journal of Information Systems and Project Management*, *3*(1):29-48. Available from: https://aisel.aisnet.org/ijispm/vol3/iss1/3/

[2] Huter, K., Krick, T., Domhoff, D., Seibert, K., Wolf-Ostermann, K. and Rothgang, H. 2020. Effectiveness of digital technologies to support nursing care: results of a scoping review. *Journal of multidisciplinary healthcare*, *13:*1905. Available from: https://www.tandfonline.com/doi/pdf/10.2147/JMDH.S286193

[3] Tsegaye, T. and Flowerday, S. 2021. A system architecture for ensuring interoperability in a South African national electronic health record system. *South African Computer Journal*, *33*(1):79-110. Available from: https://journals.co.za/doi/abs/10.18489/sacj.v33i1.838

[4] World Health Organization, 2019. Recommendations on digital interventions for health system strengthening: WHO guideline. In *Recommendations on digital interventions for health system strengthening: WHO guideline* (pp. 150-150). Available from: https://www.who.int/publications/i/item/9789241550505

[5] Krick, T., Huter, K., Domhoff, D., Schmidt, A., Rothgang, H. and Wolf-Ostermann, K. 2019. Digital technology and nursing care: a scoping review on acceptance, effectiveness and efficiency studies of informal and formal care technologies. *BMC health services research*, *19*(1):1-15. Available from: https://link.springer.com/article/10.1186/s12913-019-4238-3

[6] Seibert, K., Domhoff, D., Huter, K., Krick, T., Rothgang, H. and Wolf-Ostermann, K. 2020. Application of digital technologies in nursing practice: results of a mixed methods study on nurses' experiences, needs and perspectives. *Zeitschrift für Evidenz, Fortbildung und Qualität im Gesundheitswesen*, *158:*94-106. Available from: https://www.sciencedirect.com/science/article/pii/S1865921720301720

[7] Barbosa, S.D.F.F., Abbott, P. and Dal Sasso, G.T. 2021. Nursing in the digital health era. *Journal of Nursing Scholarship*, *53*(1):5-6. Available from: https://www.proquest.com/docview/2479483568?pq-origsite=gscholar&fromopenview=true

[8] Ali, S., Kleib, M., Paul, P., Petrovskaya, O. and Kennedy, M. 2022. Compassionate nursing care and the use of digital health technologies: A scoping review. *International Journal of Nursing Studies,* 104161. Available from: https://www.sciencedirect.com/science/article/pii/S0020748921003060?casa_token=tt3REefsjfcAAAAA:cXOvHx55G0twjkM6hW7MdB5c0AGHfXpxuMlAIGNBChaBFUXOWqF1hVrcz0yl93Gfhpd8s-7g36o

[9] Granados-Pembertty, Y.Y. and Arias-Valencia, M.M. 2013. Being in front of the patient. Nurse-patient interaction and use of technology in emergency services. *Investigación y Educación en Enfermería*, *31*(3):421-432. Available from: https://dialnet.unirioja.es/servlet/articulo?codigo=4630704

[10] Tunlind, A., Granström, J. and Engström, Å. 2015. Nursing care in a high-technological environment: Experiences of critical care nurses. *Intensive and critical care nursing*, *31*(2):116-123. Available from: https://www.sciencedirect.com/science/article/pii/S0964339714000810?casa_token=UsmjZnoHkD8AAAAA:5G4zHS9kF1rkiINuvRdXbuv-xEDOmmPgC5NnZfDv-LLUH-cNMQ9RL0WagHmGx2YCYotyNVufErk

[11] Limbu, S., Kongsuwan, W. and Yodchai, K. 2019. Lived experiences of intensive care nurses in caring for critically ill patients. *Nursing in critical care*, *24*(1):9-14. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1111/nicc.12349?casa_token=Rv-oAaMWjdoAAAAA:rtIP9zBgFWsUBW0-VaVO8L42HuKEtoaP4qWBQWFRSr1-upya-tyWIO2_adP7eXXGY2ogWyw7QPxhpB8

[12] Cornell, P., Herrin-Griffith, D., Keim, C., Petschonek, S., Sanders, A.M., D'mello, S., Golden, T.W. and Shepherd, G. 2010. Transforming nursing workflow, part 1: the chaotic nature of nurse activities. *JONA: The Journal of Nursing Administration*, *40*(9):366-373. Available from: https://journals.lww.com/jonajournal/Abstract/2010/09000/Transforming_Nursing_Workflow,_Part_1__The_Chaotic.6.aspx

[13] Vargas, I., Garcia-Subirats, I., Mogollón-Pérez, A.S., Ferreira-de-Medeiros-Mendes, M., Eguiguren, P., Cisneros, A.I., Muruaga, M.C., Bertolotto, F. and Vázquez, M.L. 2018. Understanding communication breakdown in the outpatient referral process in Latin America: a cross-sectional study on the use of clinical correspondence in public healthcare networks of six countries. *Health policy and planning*, *33*(4):494-504. Available from: https://academic.oup.com/heapol/article/33/4/494/4857369

[14] Bagayoko, C.O., Tchuente, J., Traoré, D., Moukoumbi Lipenguet, G., Ondzigue Mbenga, R., Koumamba, A.P., Ondjani, M.C., Ndjeli, O.L. and Gagnon, M.P. 2020. Implementation of a national electronic health information system in Gabon: a survey of healthcare providers' perceptions. *BMC medical informatics and decision making*, *20*(1):1-9. Available from: https://bmcmedinformdecismak.biomedcentral.com/articles/10.1186/s12911-020-01213-y

[15] Cifra, C.L., Sittig, D.F. and Singh, H. 2021. Bridging the feedback gap: a sociotechnical approach to informing clinicians of patients' subsequent clinical course and outcomes. *BMJ Quality & Safety,* 30:591-597. Available from: https://qualitysafety.bmj.com/content/30/7/591.abstract

[16] Bagherian, B., Sabzevari, S., Mirzaei, T. and Ravari, A. 2017. Effects of technology on nursing care and caring attributes of a sample of Iranian critical care nurses. *Intensive and Critical Care Nursing*, *39:*18-27. Available from:https://www.sciencedirect.com/science/article/pii/S0964339716301021?casa_token=-aGwqC4FuZgAAAAA:OnsS6GfTdVw3bMkRbyRdVagqY5ZGvVKdmu4ZD4g0b0VM8wkqeOFBy-j0RViPFJ9GhqyJHvUdCHg

[17] Needleman, J. 2013. Increasing acuity, increasing technology, and the changing demands on nurses. *Nursing Economics*, *31*(4):200. Available from: https://www.proquest.com/docview/1435379868?pq-origsite=gscholar&fromopenview=true

[18] Eley, R., Fallon, T., Soar, J., Buikstra, E. and Hegney, D. 2008. Nurses' confidence and experience in using information technology. *The Australian Journal of Advanced Nursing, 25*(3):23-35. Available from: https://search.informit.org/doi/abs/10.3316/INFORMIT.252899039910579

[19] While, A. and Dewsbury, G. 2011. Nursing and information and communication technology (ICT): a discussion of trends and future directions. *International journal of nursing studies*, *48*(10):1302-1310. Available from: https://www.sciencedirect.com/science/article/pii/S0020748911000873?casa_token=wq2bLPhC7yMAAAAA:mhp_3hrbeZylcgPQuprMiSaBl8mKqHPX9JcZWxKlA8zUUKsHxMG0oR3ovtArmOPw7Tvt3EYROyo

[20] Brown, J., Pope, N., Bosco, A.M., Mason, J. and Morgan, A. 2020. Issues affecting nurses' capability to use digital technology at work: an integrative review. *Journal of clinical nursing*, *29*(15-16):2801-2819. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1111/jocn.15321?casa_token=jyHubtoevmEAAAAA:G3sP2ekDnG22NmS3rNZ5iG9tg815XG07KCIIlsfM-LAeJXhqNMDgGCn42rmD7kfRDSqLyF4iB04VG2I

[21] Hack-Polay, D., Mahmoud, A.B., Ikafa, I., Rahman, M., Kordowicz, M. and Verde, J.M. 2022. Steering resilience in nursing practice: Examining the impact of digital innovations and enhanced emotional training on nurse competencies. *Technovation,* 102549. Available from: https://www.sciencedirect.com/science/article/pii/S0166497222000967

[22] Ludwick, D.A. and Doucette, J. 2009. Adopting electronic medical records in primary care: lessons learned from health information systems implementation experience in seven countries. *International journal of medical informatics*, *78*(1):22-31. Available from: https://www.sciencedirect.com/science/article/pii/S1386505608000920?casa_token=vJ65iC5qt7sAAAAA:EvqoDj5FJbzQyB4-fTsEDVuRbj5yHcj75wNz6yVkZRSGURufeWPiZk0H2H5xK8d8xnNdKmzhV_I

[23] Boonstra, A. and Broekhuis, M. 2010. Barriers to the acceptance of electronic medical records by physicians from systematic review to taxonomy and interventions. *BMC health services research*, *10*(1):1-17. Available from: https://bmchealthservres.biomedcentral.com/articles/10.1186/1472-6963-10-231

[24] Mather, C., Cummings, E. and Gale, F. 2019.Technology adoption in Australian healthcare environments: Nurses as stakeholders. *JMIR Nursing* 2(1):e14279. Available from: https://nursing.jmir.org/2019/1/e14279

[25] De Leeuw, J.A., Woltjer, H. and Kool, R.B., 2020. Identification of factors influencing the adoption of health information technology by nurses who are digitally lagging: in-depth interview study. *Journal of Medical Internet Research*, *22*(8):e15630. Available from: https://www.jmir.org/2020/8/e15630/

[26] Frechette, J., Bitzas, V., Aubry, M., Kilpatrick, K. and Lavoie-Tremblay, M. 2020. Capturing lived experience: Methodological considerations for interpretive phenomenological inquiry. *International Journal of Qualitative Methods*, *19*:1609406920907254. Available from: https://journals.sagepub.com/doi/pdf/10.1177/1609406920907254

[27] Ngwatu, B.K., Nsengiyumva, N.P., Oxlade, O., Mappin-Kasirer, B., Nguyen, N.L., Jaramillo, E., Falzon, D. and Schwartzman, K., 2018. The impact of digital health technologies on tuberculosis treatment: a systematic review. *European Respiratory Journal*, *51*(1). Available from https://erj.ersjournals.com/content/51/1/1701596?ctkey=shareline

[28] Manyati, Tarisai Kudakwashe, and Morgen Mutsau. "A Systematic Review of the Factors That Hinder the Scale up of Mobile Health Technologies in Antenatal Care Programmes in Sub-Saharan Africa." *African journal of science, technology, innovation and development* 13.1 (2021): 125–131. Web. Available from: https://journals.co.za/doi/abs/10.1080/20421338.2020.1765479

[29] Polit, D.F. and Beck, C.T. 2013. Is there still gender bias in nursing research? An update. *Research in nursing & health*, *36*(1):75-83. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1002/nur.21514?casa_token=vmO3k9Lj-pcAAAAA:AE25KXGuSZ97y2deUqAN8i8XYcyHhTHlooVQUZ_yv61oBkTvwqqejWP7W3gxDVHQtUZUQfVVNm5Atzk

[30] May, C., Finch, T., Mair, F., Ballini, L., Dowrick, C., Eccles, M., Gask, L., MacFarlane, A., Murray, E., Rapley, T. and Rogers, A. 2007. Understanding the implementation of complex interventions in health care: the normalization process model. *BMC health services research*, *7*(1):1-7. Available from: https://bmchealthservres.biomedcentral.com/articles/10.1186/1472-6963-7-148

[31] Murray, E., Treweek, S., Pope, C., MacFarlane, A., Ballini, L., Dowrick, C., Finch, T., Kennedy, A., Mair, F., O'Donnell, C. and Ong, B.N. 2010. Normalisation process theory: a framework for developing, evaluating and implementing complex interventions. *BMC medicine*, *8*(1):1-11. Available from: https://link.springer.com/article/10.1186/1741-7015-8-63

[32] McCarthy, S., Fitzgerald, C., Sahm, L., Bradley, C. and Walsh, E.K., 2022. Patient-held health IT adoption across the primary-secondary care interface: a Normalisation Process Theory perspective. *Health Systems,* 11(1):17-29. Available from: https://www.tandfonline.com/doi/abs/10.1080/20476965.2020.1822146

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Exploring Ghanaian Tertiary Students' Perceptions Towards AI as a First-Hand Source of Health Information for Diagnosis and Self-Medication

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Background and Purpose: The rapid advancement of Artificial Intelligence (AI) has opened new avenues in various sectors, including healthcare. In Ghana, where healthcare resources are limited, AI has the potential to bridge the accessibility gap and provide cost-effective health information and services. Therefore, this study aimed to explore Ghanaian tertiary students' perceptions toward AI-driven health information platforms. The study's objectives align with the broader impact of AI-driven health information platforms, emphasizing the need to assess awareness, trust, factors influencing willingness to use AI, and potential concerns among Ghanaian tertiary students.

Methods: The study employed a cross-sectional survey design to gather quantitative data from 50 Ghanaian tertiary students using structured questionnaires. Open-ended responses related to concerns and reservations regarding AI as a health information source were analyzed using thematic analysis. Themes and patterns were identified.

Results: The findings revealed that approximately 56% of respondents knew of AI-driven health platforms, with "Ada" being the most recognized. Trust in AI-based health information varied based on age and gender, with young females exhibiting the highest trust. Factors influencing willingness to use AI included perceived usefulness, perceived ease of use, positive prior experiences, and technological literacy.

Conclusions: The study recommends educational campaigns, enhancing trust, user-friendly platforms, academic integration of AI education, and addressing ethical considerations to promote AI adoption in healthcare decision-making among Ghanaian tertiary students. These insights can inform policymakers and healthcare providers in developing effective strategies to harness AI's transformative potential in healthcare accessibility in Ghana.

Keywords: Artificial Intelligence, healthcare delivery, Ada, Technology Acceptance Model (TAM), Ghana

1 Introduction

1.1 Background

The rapid advancement of Artificial Intelligence (AI) in recent years has led to transformative changes in various sectors, with healthcare being a prominent area of exploration. AI's potential to provide health information, diagnosis, and self-medication tools has garnered significant attention from researchers and healthcare professionals (Bohr & Memarzadeh, 2020; Topol, 2019). Integrating AI-driven health platforms, mobile applications, and chatbots has paved the way for accessible and convenient medical information and self-assessment tools for users (Esmaeilzadeh, 2020).

AI-driven health platforms offer numerous benefits, especially in regions with limited healthcare resources like Ghana (Ampofo et al., 2023; Ghana Web, 2023). The country has been actively working to improve its healthcare system. Still, challenges such as inadequate healthcare infrastructure, limited access to medical professionals, and a shortage of health education opportunities persist (Koduah et al., 2021). In such contexts, AI has the potential to bridge the healthcare accessibility gap, providing a cost-effective and scalable solution to deliver essential health information and services. For instance, AI-powered chatbots and mobile applications can act as virtual healthcare assistants, providing timely and accurate information

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to users about common health conditions, symptoms, and self-care measures. Users can access these resources conveniently from their smartphones, making healthcare information readily available, particularly to Ghanaian tertiary students who are digitally connected and technologically inclined.

The objectives of this study align with the broader implications of AI-driven health information platforms. The first objective aims to assess Ghanaian tertiary students' awareness of AI-driven health information platforms. As AI continues to permeate healthcare settings globally, understanding the extent of awareness among students is essential to gauge the potential adoption and acceptance of AI-driven health information solutions. The second objective delves into the trust levels of Ghanaian tertiary students toward AI-based health information for diagnostic purposes. Trust is a critical factor influencing the acceptance and usage of AI technologies in healthcare (Topol, 2019). Establishing high trust in AI for diagnostic purposes is crucial for its successful integration into healthcare practices, empowering users to make informed decisions about their health. The third objective seeks to identify the factors influencing the willingness of Ghanaian tertiary students to use AI for self-medication and health-related decision-making. This exploration will shed light on the underlying motivators and barriers to adopting AI for self-care practices, thereby guiding the

development of tailored and user-centric AI applications. Lastly, the fourth objective aims to explore any potential concerns or reservations Ghanaian tertiary students may have regarding AI as a health information source. Ethical considerations and privacy platforms are pertinent when dealing with AI-driven health platforms, and understanding these reservations will help devise strategies to address them effectively, ensuring responsible and ethical AI usage in healthcare settings.

In summary, the study highlights the transformative potential of AI in healthcare, particularly its implications for healthcare accessibility and affordability in regions like Ghana. The study's objectives align with the broader impact of AI-driven health information platforms, emphasizing the need to assess awareness, trust, factors influencing willingness to use AI, and potential concerns among Ghanaian tertiary students. Through rigorous research and analysis, this study aims to contribute to the broader understanding of AI adoption in healthcare, fostering informed decision-making and policy development to leverage AI's benefits in transforming healthcare accessibility in Ghana.

1.2 Problem Statement

Ghana, located in West Africa, has been striving to enhance its healthcare system. However, several challenges persist, hindering the delivery of quality healthcare to its population. A study by (Koduah et al., 2021) revealed inadequate healthcare infrastructure, limited access to medical professionals, and low health education levels. These challenges have significant implications for the health outcomes and decision-making practices of the country's youth, including tertiary students.

As the younger generation in Ghana becomes more technologically inclined, understanding their perceptions and attitudes toward AI in health information is crucial. AI has the potential to revolutionize healthcare by improving health information dissemination, diagnosis, and treatment. For Ghana's healthcare system to overcome its existing challenges, it is essential to explore how AI can be effectively integrated into health information and how the youth perceive its adoption in their healthcare decision-making processes.

By investigating the adoption and perceptions of AI in health information among Ghana's youth population, the study aims to address the problem of inadequate healthcare infrastructure, limited access to medical professionals, and low health education levels. The insights gained from this research will help inform strategies to harness the potential of AI in healthcare and promote its acceptance among the youth. Ultimately, this can contribute to shaping more informed healthcare decisions and practices, potentially leading to improved health outcomes for the people of Ghana.

1.3 Research Aim and Objectives

This study aims to investigate Ghanaian tertiary students' perceptions of using AI as a first-hand source of health information for diagnosis and self-medication. The specific objectives are as follows:

1. To assess Ghanaian tertiary students' awareness of AI-driven health information platforms.

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2. To examine the trust levels of Ghanaian tertiary students towards AI-based health information for diagnostic purposes.
3. To identify the factors influencing the willingness of Ghanaian tertiary students to use AI for self-medication and health-related decision-making.
4. To explore any potential concerns or reservations Ghanaian tertiary students may have regarding AI as a health information source.

1.4 Research Questions

The research questions guiding this study are:

1. What is the level of awareness among Ghanaian tertiary students regarding AI-driven health information platforms?
2. How much trust do Ghanaian tertiary students place in AI-based health information for diagnostic purposes?
3. What factors influence the willingness of Ghanaian tertiary students to use AI for self-medication and health-related decision-making?
4. What are the concerns and reservations of Ghanaian tertiary students regarding AI as a first-hand source of health information?

1.5 Significance of the Study

This study's findings will contribute to understanding AI's role in shaping healthcare decisions and practices among Ghanaian tertiary students. It will shed light on their awareness, trust, and willingness to use AI-driven health information platforms, which can inform policymakers, healthcare providers, and AI developers about potential strategies for improving healthcare access and education.

1.6 Scope and Limitations

This study focuses on Ghanaian tertiary students aged between 18 and 30 years, attending various universities and colleges in different regions of Ghana. The research will be limited to a quantitative approach, which may restrict a comprehensive exploration of participants' perceptions and lacks review board approval. The study's generalizability might also be limited to the population under investigation.

2 Literature Review

2.1 Theoretical Review

The conceptual framework of this study is based on the Technology Acceptance Model (TAM) proposed by (Davis, 1989). TAM is widely used to understand individuals' acceptance and adoption of new technologies, including AI applications in healthcare (Venkatesh & Davis, 2000). According to TAM, two primary factors influence technology acceptance: perceived usefulness and perceived ease of use. Perceived usefulness refers to the extent to which individuals believe that using technology will enhance their performance, while perceived ease of use refers to the degree to which individuals perceive that the technology will be effortless. As shown in Figure 1 is the conceptual framework of the study.

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2.2 Conceptual Framework

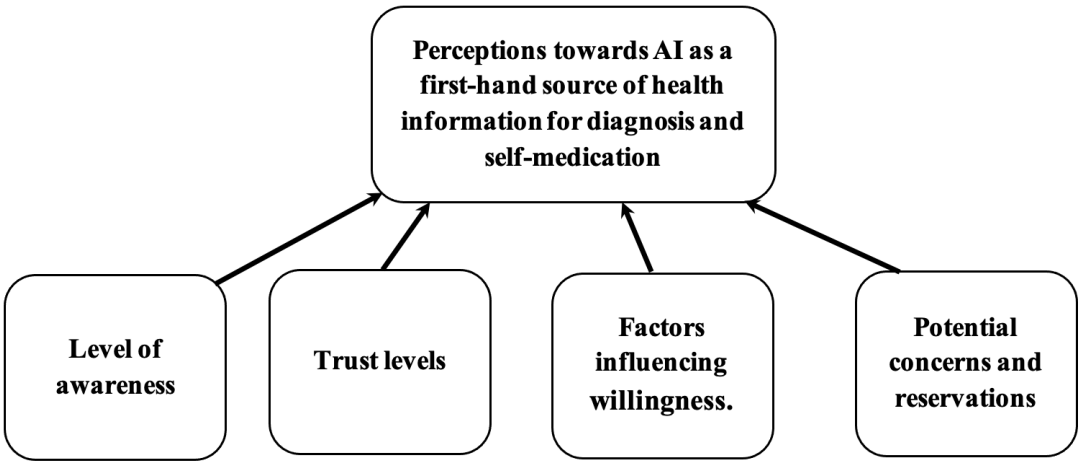

Figure 1. Conceptual Framework

In the context of this study, the conceptual framework posits that Ghanaian tertiary students' perceptions towards AI-driven health information platforms (Objectives 1 and 2) will be influenced by their perceived usefulness in obtaining accurate health information and their perceived ease of use in navigating and interacting with AI-based systems. Additionally, technological literacy, trust in AI, and prior experiences with AI applications will mediate the students' perceptions.

2.3 Empirical Review

2.3.1 Awareness of AI-Driven Health Information Platforms

Studies have explored AI's potential to provide health information and support self-diagnosis. However, limited research has explicitly focused on the awareness of AI-driven health information platforms among Ghanaian tertiary students. Previous research in other contexts has demonstrated that individuals' understanding of AI applications can significantly impact their acceptance and usage of AI technologies (Jain et al., 2022). Thus, exploring the level of awareness among Ghanaian tertiary students (Objective 1) is crucial for understanding their readiness to embrace AI-based health information solutions.

2.3.2 Trust in AI-Based Health Information for Diagnostic Purposes

Trust is a fundamental factor influencing technology adoption, and it is especially critical in the context of AI applications in healthcare. Previous studies have shown that accuracy, transparency, and human oversight can influence individuals' trust in AI's diagnostic capabilities (Topol, 2019). Examining the trust levels of Ghanaian tertiary students towards AI-based health information for diagnostic purposes (Objective 2) will provide insights into their confidence in AI-driven diagnostics and its potential impact on their health-related decision-making.

2.3.3 Factors Influencing Willingness to Use AI for Self-Medication and Health Decision-Making

Various factors influence the acceptance and adoption of AI-driven health information platforms. Previous research has shown that factors such as perceived usefulness, perceived ease of use, technological literacy, and prior experiences with AI applications play vital roles in individuals' willingness to engage with AI in healthcare decision-making and self-medication practices (Venkatesh & Davis, 2000); (Albusalih et al., 2017). Identifying these factors (Objective 3) will enable us to understand the drivers and barriers to AI adoption among Ghanaian tertiary students.

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2.3.4 Concerns and Reservations Regarding AI as a Health Information Source

While AI presents promising opportunities in healthcare, it also raises concerns about privacy, data security, and the potential for misdiagnosis (Topol, 2019). Understanding Ghanaian tertiary students' concerns and reservations regarding AI as a health information source (Objective 4) is essential for addressing potential ethical and educational challenges.

3 Methods

This study employed a cross-sectional survey design to gather quantitative data from Ghanaian tertiary students. The survey was conducted in different universities and colleges across various regions of Ghana to ensure a diverse and representative sample.

3.1 Participants and Sampling

The target population for this study was Ghanaian tertiary students aged between 18 and 30 years. A stratified random sampling technique selected participants from different faculties or departments within each university or college. The sample size was determined using a confidence level of 95% and a margin of error of 5%. A total of 50 participants were considered for this study.

3.2 Data Collection

Data was collected through a structured questionnaire designed to address each research objective. The questionnaire consisted of closed-ended and Likert scale-based questions to quantify participants' perceptions and attitudes.

3.3 Data Analysis

3.3.1 To assess the level of awareness among Ghanaian tertiary students regarding AI-driven health information platforms.

Descriptive statistics were used to calculate the percentage of participants aware of AI-driven health information platforms. Subgroup analysis compared awareness levels across different demographic variables, such as gender, age, and academic discipline.

3.3.2 To examine the trust levels of Ghanaian tertiary students towards AI-based health information for diagnostic purposes.

Participants' responses on the Likert scale regarding their trust in AI-based health information for diagnostic purposes were analyzed using descriptive statistics. The mean and standard deviation were calculated to measure the overall trust levels. Inferential statistics, such as correlation, were also used to compare trust levels between different demographic groups.

3.3.3 To identify the factors influencing the willingness of Ghanaian tertiary students to use AI for self-medication and health-related decision-making.

Descriptive statistics were used to group respondents' answers under the themes of perceived usefulness, perceived ease of use, technological literacy, and prior experiences with AI to identify factors influencing willingness to use AI. The theme with the highest frequency and percentage was the most influential factor.

3.3.4 To explore any potential concerns or reservations Ghanaian tertiary students may have regarding AI as a health information source.

Open-ended responses related to concerns and reservations regarding AI as a health information source were analyzed using thematic analysis. Themes and patterns were identified. Responses under themes were

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quantified to determine which concern was dominant. Table 1 presents each objective, variables analyzed, description, and units of analysis of the study.

Objective	Variables Analyzed	Description	Unit of Analysis
Objective 1: To assess the level of awareness among Ghanaian tertiary students regarding AI-driven health information platforms.	Awareness of AI-driven Health Platforms	This variable assesses participants' awareness of AI-driven health information platforms.	Individual (Participant)
	AI-driven Health Information Platforms	This variable captures specific AI-driven health information platforms known to participants, if any.	Individual (Participant)
	Gender	This variable records the participants' gender.	Individual (Participant)
	Age	This variable records participants' age in years.	Individual (Participant)
	Academic Discipline	This variable categorizes participants based on their academic discipline.	Individual (Participant)
Objective 2: To examine the trust levels of Ghanaian tertiary students towards AI-based health information for diagnostic purposes.	Trust in AI-based Health Information	This variable assesses participants' level of trust in AI-based health information for diagnostic purposes.	Individual (Participant)
Objective 3: To identify the factors influencing the willingness of Ghanaian tertiary students to use AI for self-medication and health-related decision-making.	Willingness to Use AI for Self-Medication	This variable assesses participants' willingness to use AI for self-medication and health-related decision-making.	Individual (Participant)
	Perceived Usefulness	This variable measures participants' perception of the usefulness of AI for self-medication.	Individual (Participant)
	Perceived Ease of Use	This variable measures participants' perception of the ease of using AI for self-medication.	Individual (Participant)
	Technological Literacy	This variable assesses participants' comfort level in using technology.	Individual (Participant)
	Prior Experiences with AI	This variable captures participants' past experiences with AI in other applications.	Individual (Participant)
Objective 4: To explore any potential concerns or reservations Ghanaian tertiary students may have regarding AI as a health information source.	Concerns/Reservations Regarding AI	This variable captures participants' concerns or reservations regarding AI as a health information source.	Individual (Participant)

Table 1 Description of variables and units of analysis

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3.4 Ethical Considerations

The study adhered to ethical guidelines, ensuring confidentiality, informed consent, and voluntary participation of the participants. An informed consent form was provided to all participants, and they could withdraw from the study at any time.

3.5 Validity and Reliability

To ensure the validity of the survey instrument, a pilot test was conducted with a small group of participants before the primary data collection. Necessary adjustments were made based on the pilot test's feedback. Internal consistency checks, such as Cronbach's alpha, were calculated for relevant sections of the questionnaire to establish reliability.

3.6 Limitations

Despite efforts to ensure representativeness, the study's findings might be limited to the specific population of Ghanaian tertiary students. Additionally, the cross-sectional nature of the survey design limits causal inferences. The study was conducted without review board approval; therefore, the author acknowledges this limitation and ethical consideration. associated with this.

4 Results & Discussions

4.1 Profile of Respondents

4.1.1 Age

The study's respondents were predominantly young, with 31 participants aged between 18 and 24 years and 19 participants falling in the 25 to 30-year age range. This age distribution suggests a greater representation of younger individuals. Understanding potential variations in perceptions and attitudes towards AI-driven health information platforms between these age groups could provide valuable insights. The age distribution is also relevant in generalizing the study's findings to the wider population of Ghanaian tertiary students. As shown in Figure 2 is the graphical representation of the ages of respondents who participated in the study.

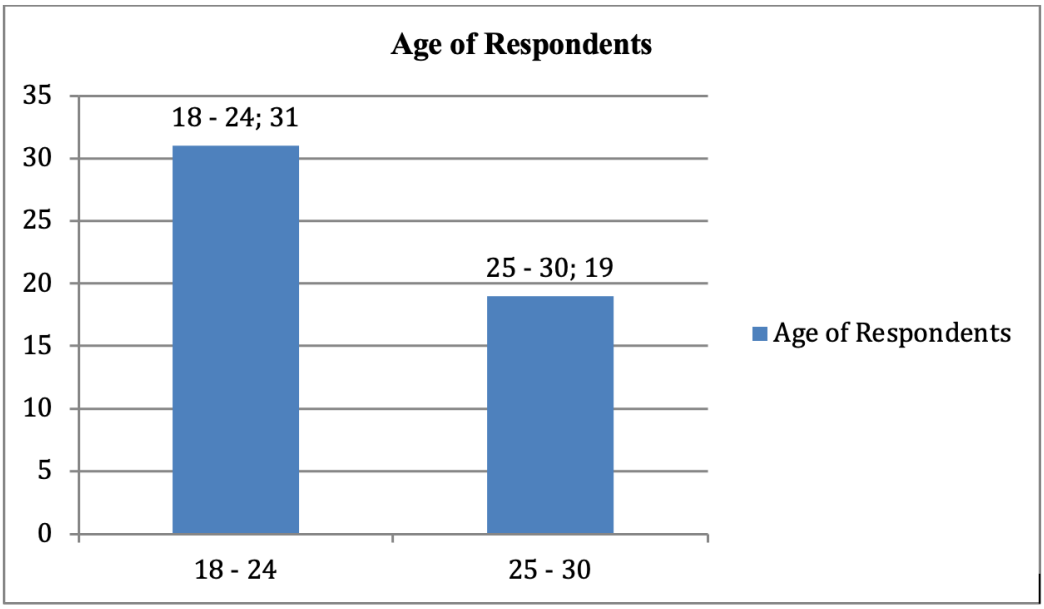

Figure 2: Graphical representation of respondents' ages

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4.1.2 Gender

The study's respondents comprised 23 males (46%) and 27 females (54%), indicating a balanced gender representation. This balance enables comprehensive insights into perceptions of AI-driven health information platforms, including potential gender-specific variations. Analyzing differences in awareness, trust, and willingness to use AI between males and females could aid policymakers in developing inclusive AI healthcare solutions. The gender distribution also enhances the study's generalizability to the wider population of Ghanaian tertiary students.

4.1.3 Academic Discipline

The table below displays the distribution of academic disciplines among Ghanaian tertiary students in the study. Humanities had the highest representation with 15 students, followed by Business/Economics and Engineering/Technology with ten each. Health Sciences/Medicine, Natural Sciences, and Social Sciences had five students, while 5 participants belonged to other disciplines. This diverse representation ensures a comprehensive perspective on perceptions towards AI-driven health information platforms among Ghanaian students. Further analysis may explore potential variations in attitudes across different disciplines.

4.2 Assessing awareness among Ghanaian tertiary students regarding AI-driven health information platforms.

4.2.1 Awareness of AI-driven health information platforms

Approximately 56% of respondents were aware of AI-driven health information platforms, while 44% were unaware. The findings suggest a notable level of familiarity among Ghanaian tertiary students. However, 44% were unaware, highlighting the need for increased healthcare education and awareness about AI. Addressing this gap can foster greater acceptance and utilization of AI-driven health platforms among students. As shown in Figure 3 is the graphical representation of respondents' awareness of AI-driven health information platforms.

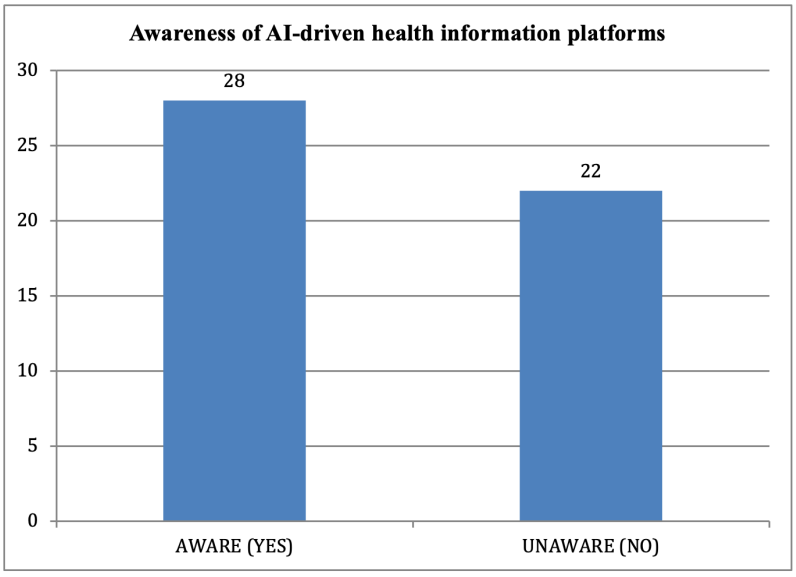

Figure 3: Respondents' awareness of AI-driven health information platforms

4.2.2 Specific AI-driven health information platforms respondents were aware of

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The data shows respondents' awareness of specific AI-driven health platforms. "Ada" had the highest recognition (14), followed by "Buoy" (10) and "Babylon Health" (9). Four respondents mentioned other platforms. The findings suggest these platforms have notable awareness among Ghanaian tertiary students. Acknowledging different responses highlights the need to consider diverse AI healthcare solutions. Tailoring efforts based on this data can promote students' engagement with AI technologies in healthcare.

These findings are also aligned with studies by (Jain et al., 2022) that individuals who were aware of AI applications were more likely to accept and use them. As shown in Figure 4 is a pie chart that shows the data about the AI-driven health platforms respondents are aware of.

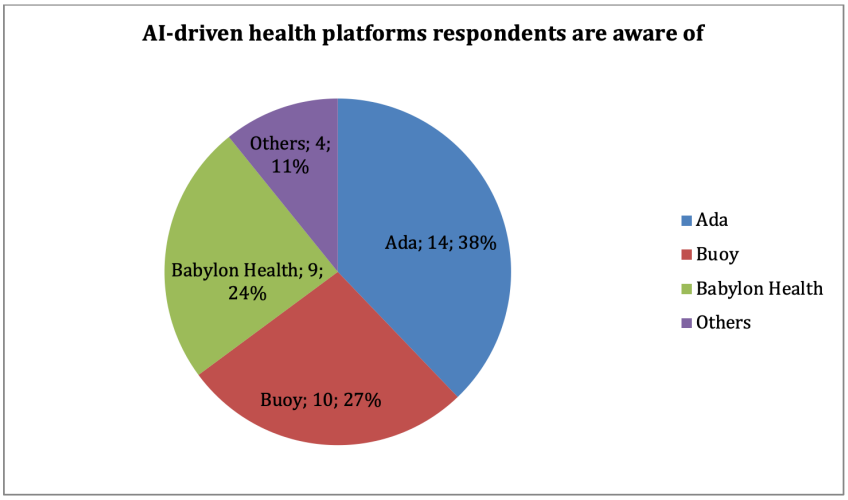

Figure 4: AI-driven health platforms respondents are aware of

4.3 Examining the trust levels of Ghanaian tertiary students towards AI-based health information for diagnostic purposes.

For this analysis, let us assign the following values:

- No trust at all: 1
- Low trust: 2
- Neutral: 3
- High trust: 4
- Complete trust: 5

Calculating the mean and standard deviation for each age and gender group:

Trust levels of males between ages 18-24 years

1, 2, 3, 4, 5, 4, 4, 4, 4, 4, 4, 4, 5, 5, 3

Mean = (1 + 2 + 3 + 4 + 5 + 4 + 4 + 4 + 4 + 4 + 4 + 4 + 5 + 5 + 3) / 15 = 3.67

Standard Deviation = $\sqrt{[((1-3.67)^2 + (2-3.67)^2 + (3-3.67)^2 + \ldots + (5-3.67)^2) / 15]} \approx 1.03$

Trust levels of females between ages 18-24 years

4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4

Mean = (4 + 4 + 4 + ... + 4) / 32 = 4.00

Standard Deviation = $\sqrt{[((4-4)^2 + (4-4)^2 + \ldots + (4-4)^2) / 32]} = 0$

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Trust levels of males within 25-30 years

4, 3, 3, 2, 2, 2, 2, 2

Mean = (4 + 3 + 3 + 2 + 2 + 2 + 2 + 2) / 8 = 2.50

Standard Deviation = √[((4−2.50)x2 + (3−2.50)x2 + (3−2.50)x2 + ... + (2−2.50)x2) / 8] ≈ 0.61

Age group: 25-30 years, Female Trust Levels

3, 3, 1, 1, 1, 3, 2, 2, 2, 2, 3, 2, 2, 2

Mean = (3 + 3 + 1 + 1 + 1 + 3 + 2 + 2 + 2 + 2 + 3 + 2 + 2 + 2) / 14 = 2.07

Standard Deviation = √[((3-2.07)x2 + (3-2.07)x2 + (1-2.07)x2 + ... + (2-2.07)x2) / 14] ≈ 0.74

The findings reveal variations in trust levels towards AI-based health information among Ghanaian tertiary students based on age and gender. Young females aged 18-24 exhibit the highest and most consistent trust (mean = 4.00, SD = 0). Young males in the same age group also express moderate trust (mean = 3.67, SD = 1.03). In contrast, older males (mean = 2.50, SD = 0.61) and females (mean = 2.07, SD = 0.74) aged 25-30 display lower trust levels. The results imply that young females aged 18-24 are most trusting of AI-based health information, followed by young males. However, older males and females aged 25-30 have lower and more varied trust levels. Age and gender influence perceptions of AI's reliability for healthcare purposes. Trust levels were mainly influenced by concerns such as accuracy, transparency, and human oversight (Topol, 2019).

4.3 Identify the factors influencing the willingness of Ghanaian tertiary students to use AI for self-medication and health-related decision-making.

The chart below reveals that perceived usefulness, perceived ease of use, positive prior experiences with AI, and technological literacy significantly influence Ghanaian tertiary students' willingness to use AI for health-related decision-making. Around 20 respondents recognize AI's usefulness, 23 consider AI platforms user-friendly, ten feel comfortable using technology, and 21 have positive AI experiences. Understanding these factors can inform strategies to promote AI adoption in healthcare decision-making among students. Findings validate the research assertion that perceived usefulness, perceived ease of use, technological literacy, and prior experiences with AI applications play vital roles in individuals' willingness to engage with AI in healthcare decision-making and self-medication practices (Venkatesh & Davis, 2000); (Albusalih et al., 2017). As shown in Figure 5 is a pie chart that shows the data about factors influencing willingness to use AI for health-related decision-making.

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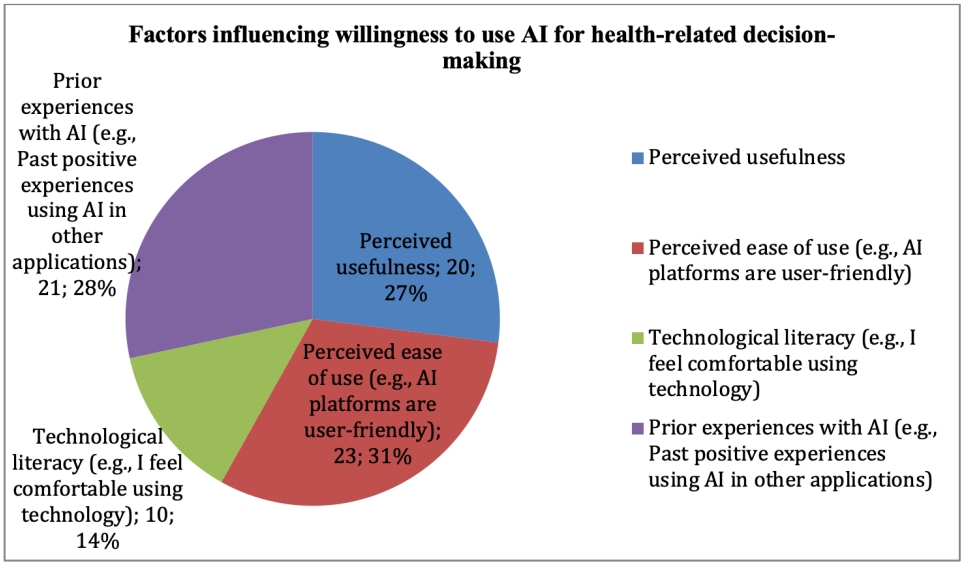

Figure 5: Factors influencing willingness to use AI for health-related decision-making.

4.5 Explore any potential concerns or reservations Ghanaian tertiary students may have regarding AI as a health information source

The data reveals that Ghanaian tertiary students harbor various concerns about AI as a health information source. With 15 students worried about AI providing wrong information, 10 fearing internet connectivity issues during emergencies, 12 concerned about device compatibility, and 13 expressing apprehension about subscription costs, it is evident that trust, accessibility, and financial considerations are significant barriers. Similar concerns were also gathered (Topol, 2019). Addressing these concerns through improved AI accuracy, offline accessibility, device compatibility, and affordable options can enhance students' confidence and adoption of AI-driven health information platforms.

5 Conclusion

This study aimed to explore Ghanaian tertiary students' perceptions of AI as a first-hand source of health information for diagnosis and self-medication. The research objectives were to assess awareness levels, examine trust in AI-based health information, identify factors influencing willingness to use AI and explore concerns and reservations regarding AI in healthcare. The study findings shed light on key insights that can contribute to the understanding and accepting AI-driven health information platforms among Ghanaian tertiary students. The profile of respondents revealed a young and balanced gender representation, providing a representative sample of Ghanaian tertiary students. Approximately 56% of respondents knew of AI-driven health information platforms, with "Ada" being the most recognized. This suggests a notable level of familiarity among the students. However, 44% unaware highlights the need for increased education and awareness about AI in healthcare. Regarding trust in AI-based health information, young females aged 18-24 exhibited the highest and most consistent trust, followed by young males in the same age group. In contrast, older males and females aged 25-30 displayed lower and more varied trust levels. Age and gender influence perceptions of AI's reliability for healthcare purposes. Factors influencing willingness to use AI for health-related decision-making included perceived usefulness, perceived ease of use, positive prior experiences with AI, and technological literacy. Understanding these factors can inform strategies to promote AI adoption in healthcare decision-making among students. Ghanaian tertiary students expressed concerns about AI as a health information source, including providing wrong information, internet connectivity issues, incompatible devices, and subscription costs. Addressing these concerns through

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improved AI accuracy, offline accessibility, device compatibility, and affordable options can enhance students' confidence and adoption of AI-driven health information platforms.

5.1 Recommendations

Based on the study findings, the following recommendations are proposed to promote the acceptance and adoption of AI-driven health information platforms among Ghanaian tertiary students:

1. ***Educational Campaigns:*** Implement educational campaigns and workshops to increase awareness about AI-driven health information platforms. Targeting students across universities and colleges will help disseminate accurate information about AI's benefits and potential applications in healthcare.
2. ***Enhancing Trust:*** Developers of AI-driven health platforms should prioritize transparency and accuracy to build user trust. Providing clear explanations of how AI algorithms work and ensuring that AI platforms undergo rigorous testing and validation will enhance users' confidence.
3. ***User Experience and Accessibility:*** Ensure that AI-driven health platforms are user-friendly and accessible to individuals with varying technological literacy levels. Optimizing platforms in low internet connectivity areas will increase usability and reach.
4. ***Academic Integration:*** Collaborate with academic institutions to integrate AI education into relevant curricula. Offering courses or workshops on AI applications in healthcare will prepare students for a future where AI is increasingly prevalent in the medical field.
5. ***Addressing Concerns:*** Address concerns regarding AI as a health information source by incorporating features that allow users to verify information, seek human assistance when needed, and provide affordable subscription options.
6. ***Ethical Considerations:*** Prioritize ethical considerations in developing and implementing AI-driven health platforms. Emphasize user data privacy, informed consent, and compliance with ethical guidelines in AI applications. Review board approval will be sought for future studies.
7. ***Collaborative Research:*** Encourage interdisciplinary collaborations between healthcare professionals, AI developers, and social scientists to gain comprehensive insights into AI's impact on healthcare decision-making and self-medication practices.

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None

Statement on conflicts of interest

No conflicts of interest

References

Albusalih, F., Naqvi, A., Ahmad, R., & Ahmad, N. (2017). Prevalence of Self-Medication among Students of Pharmacy and Medicine Colleges of a Public Sector University in Dammam City, Saudi Arabia. *Pharmacy*, *5*(4), 51. https://doi.org/10.3390/pharmacy5030051

Ampofo, J. W., Emery, C. V., & Ofori, I. N. (2023). Assessing the Level of Understanding (Knowledge) and Awareness of Diagnostic Imaging Students in Ghana on Artificial Intelligence and Its Applications in Medical Imaging. *Radiology Research and Practice*, *2023*, 1–9. https://doi.org/10.1155/2023/4704342

Bohr, A., & Memarzadeh, K. (Eds.). (2020). *Artificial intelligence in healthcare*. Academic Press, imprint of Elsevier.

Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*, *13*(3), 319. https://doi.org/10.2307/249008

Esmaeilzadeh, P. (2020). Use of AI-based tools for healthcare purposes: A survey study from consumers' perspectives. *BMC Medical Informatics and Decision Making*, *20*(1), 170. https://doi.org/10.1186/s12911-020-01191-1

Jain, R., Garg, N., & Khera, S. N. (2022). Effective human–AI work design for collaborative decision-making. *Kybernetes*. https://doi.org/10.1108/K-04-2022-0548

Koduah, A., Nonvignon, J., Colson, A., Kurdi, A., Morton, A., Van Der Meer, R., Aryeetey, G., & Megiddo, I. (2021). Health systems, population and patient challenges for achieving universal health coverage for hypertension in Ghana. *Health Policy and Planning*, *36*(9), 1451–1458. https://doi.org/10.1093/heapol/czab088

Topol, E. J. (2019). High-performance medicine: The convergence of human and artificial intelligence. *Nature Medicine*, *25*(1), 44–56. https://doi.org/10.1038/s41591-018-0300-7

Venkatesh, V., & Davis, F. D. (2000). A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. *Management Science*, *46*(2), 186–204. https://doi.org/10.1287/mnsc.46.2.186.11926

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Journal of Health Informatics in Africa

« 2arcf Systeme » Un Logiciel A Moindre Cout Pour L'interprétation du Rythme Cardiaque Fœtal

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Contexte : Madagascar, un pays en développement, a des difficultés à acquérir les nouvelles technologies médicales, parmi elles les appareils d'interprétation du rythme cardiaque fœtal (RCF). Notre étude consiste à la création d'un logiciel qui analyse automatiquement le RCF avec les ressources matérielles disponibles et l'évaluation de son efficacité.
Méthode : Le projet informatique s'est fait en deux étapes : la phase de spécifications et la phase de codage du logiciel incluant la phase test. Matrix Laboratory a été utilisé pour la création de ce logiciel.
Pour la phase test, nous avons recruté au hasard des enregistrements du RCF puis analysé le logiciel créé. Une étude prospective descriptive sur ces enregistrements a été menée et pour préciser la fiabilité des résultats du logiciel, nous avons réalisé une étude comparative de ces derniers avec l'analyse conventionnelle se basant sur la classification du RCF du CNGOF.
Résultats : Le logiciel « 2ARCF système » a été créé. Cent dix enregistrements ont été recrutés. Après analyse conventionnelle 40,9% des tracés revenaient normaux contre 61,8% après analyse informatisée avec un coefficient de concordance de kappa à 0,564. La moyenne des écarts entre les valeurs du rythme de base des deux méthodes selon la procédure décrite par Bland et Altman était de 1,249 bpm.
Conclusion : L'application « 2ARCF système » a montré sa fiabilité. Elle est un atout, surtout dans les régions éloignées de Madagascar.

Mots-clés : analyse, logiciel, Madagascar, rythme cardiaque fœtal.

1 Introduction :

Depuis la découverte du cardiotocographe par Corner et Stran en 1957, les problèmes étaient surtout liés à l'interprétation des tracés. Le rythme cardiaque fœtal (RCF) varie en fonction des événements lesquels ont une influence non négligeable sur son interprétation. D'où l'intérêt d'une interprétation la plus exacte du rythme cardiaque du fœtus. Ainsi est venue l'idée d'automatiser l'interprétation du RCF plus précisément d'analyser l'enregistrement. Plusieurs systèmes ont été déjà développés depuis aidant l'analyse et l'interprétation du RCF tels le système Sonicaid OXFORD 8000 et 8002 établi par l'équipe du Pr Dawes et Redman [1, 2], le système STAN qui a été développé et commercialisé par la société Néoventa médicale AB depuis 2000 [3, 4], le système SISPORTO développé par l'Institut National d'Ingénierie Biomédicale (INEB) à l'université de Porto en 2000 [5]. L'objectif de notre étude est de créer une application capable de scruter et de traiter les données venant du cardiotocographe et d'en sortir des résultats fiables et exacts, cette application serait utilisable et applicable dans des formations sanitaires à faibles ressources.

2 Matériels et méthode

Le projet informatique se découpe en deux grandes phases : la phase de spécifications décrite par le cahier de charge informatique et la phase de codage du logiciel incluant la phase test.

Concernant la phase de développement de l'application, la conception des algorithmes et l'élaboration des logigrammes correspondants était réalisée avec Qalitel logigramme en tenant compte des

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aspects logiques et la pertinence de la création grâce à l'aspect graphique qu'il nous procure. Ensuite, MatLab (Matrix Laboratory) était utilisé vu qu'il apporte un système interactif intégrant calcul numérique, visualisation et développement d'algorithme.

Une modélisation conceptuelle des données était appliquée à chaque paramètre ainsi que des règles de calcul :

- pour le rythme de base, c'est la moyenne quadratique des fréquences cardiaques ;
- pour la variabilité dont l'amplitude des oscillations, l'écart des amplitudes maximales et minimales avec une moyenne sur 10 minutes ;
- pour la fréquence des oscillations c'est le nombre de cycle par minute sur 10 mn ;
- pour la variabilité à long terme (VLT) : VLT/mn= (60 000 ms/ fréquence min)- (60 000 ms/fréquence max) dont VLT globale = moyenne VLT ;
- pour la variabilité à court terme (VCT), c'est la moyenne des écarts en ms ;
- pour les épisodes de haute fréquence, au moins 5 mn parmi les 6 mn consécutives
- pour les épisodes de basse fréquence, au moins 5 mn parmi les 6 mn consécutives ;
- pour les accélérations avant 32 semaines d'aménorhée (SA) : élévation fréquence ≥10 bpm par rapport ligne de base (rdb) + durée ≥10 s et <10 mn, après 32 SA : élévation fréquence ≥15 bpm par rapport ligne de base + durée ≥15 s et <10 mn ;
- pour les décélérations :
  - précoces et tardives: baisse fréquence ≥15 bpm par rapport ligne de base (rdb) + durée ≥15 s et <10 mn + nombre ralentissement/nombre CU=1,
  - épisodiques : baisse fréquence ≥15 bpm + <30 bpm par rapport ligne de base (rdb) + durée ≥15 s et ≤ 30 s,
  - prolongées : baisse fréquence ≥30 bpm par rapport ligne de base (rdb) + durée ≥2 mn et <10 mn
- pour la contraction utérine : intensité vraie= intensité totale - tonus base.

La conception et l'élaboration des algorithmes suivaient les étapes suivantes : acquisition du tracé sous format image, importation de l'image, réorientation de l'image si nécessaire, digitalisation : détermination des coordonnées par pixel, retraçage des courbes, calcul des différents paramètres, affichage des résultats, enregistrement. Un algorithme est ainsi appliqué à chaque variable étudiée.

Au cours de la phase de codage et d'implémentation, nous avons transcrit ou codé les algorithmes des différentes variables et les fonctionnalités décrites précédemment avec le langage MatLab afin d'automatiser l'analyse du RCF et d'en sortir les résultats correspondants. En d'autres termes nous avons créé le logiciel d'analyse nommée : « 2ARCF système ».

Le test du logiciel « 2ARCF Système » a été menée au Centre Hospitalier Universitaire de Gynécologie et d'Obstétrique de Befelatanana sur des enregistrements de RCF au sein de deux services à savoir le service de Grossesses à risque et le service Accouchement. Au cours de cette phase, quatre objectifs sont à atteindre : évaluer l'efficacité du système en exploitation, tester la conformité du système par rapport aux besoins, dégager une quelconque modification des spécifications d'un point de vue fonctionnel et de performance et évaluer l'impact du système sur la pratique quotidienne. Une étude interventionnelle prospective a été effectuée pour la phase test.

3 Resultats

Le logiciel « 2ARCF système » est ainsi créé, son interface (Figure 1) nécessite pour le premier démarrage de l'application l'installation de Matlab Compiler Runtime MCR 7.15.

Pour la phase test, nous avons recueilli 110 RCF dans les deux services. Les tracés résultant du monitorage fœtal en format papier étaient analysé conventionnellement ensuite étaient importé dans le logiciel « 2ARCF système » pour l'analyse informatisée, ensuite le résultat de ces deux types d'analyse ont été confrontés. Ont été inclus dans notre étude les tracés d'enregistrement du RCF de surveillance de toutes les grossesses pathologiques dont l'âge gestationnel est supérieur ou égal à 32 semaines d'aménorrhée et aussi les femmes en début de travail.

Après analyse des résultats sur Microsoft Excel par l'utilisation de fonction logique intégrée ; sur les 110 cas recueillis après l'analyse conventionnelle et informatisée 78 résultats concordaient soit 70,9%,

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selon la classification du RCF du CNGOF [6]. En effet, parmi les 29,09% non concordants, soit 20 cas après analyse conventionnelle étaient interprétés comme quasi-normale alors que le logiciel les classifiaient comme normaux selon la classification du CNGOF; de même pour les 5 autres cas que l'analyse visuelle classifiait comme intermédiaire. Un cas était pathologique après analyse visuelle et pourtant le logiciel affichait un résultat normal mais avec une variabilité à long et à court termes qui étaient douteuses et dont la probabilité d'acidose à 0% selon le calcul du logiciel. D'autre part, deux cas de risque d'acidose (intermédiaire) et un cas de faible risque d'acidose (quasi-normal) ont été identifiés par le logiciel ; alors que l'analyse conventionnelle de ces deux cas revenait normale. (Tableau I).

Tableau I : Tableau croisé des nombres de tracés des deux analyses visuelle et informatisée selon l'interprétation du CNGOF

Analyse informatisée / **Analyse visuelle**	**Normal**	**Quasi-normal**	**Intermédiaire**	**Pathologique**	**Total**
Normal	42	1	2	0	45
Quasi-normal	20	13	0	0	33
Intermédiaire	5	3	11	0	19
Pathologique	1	0	0	12	13
Total	68	17	13	12	110

Le coefficient Kappa a été utilisé pour déterminer la concordance entre l'analyse informatisée et l'analyse conventionnelle, sa valeur était de 0,564.

Concernant le rythme de base, le tableau II représentait les valeurs du rythme de base selon les deux méthodes. Le test T pour deux échantillons appariés retrouve une différence des moyennes du rythme de base de 1,249 bpm avec un intervalle de confiance à 95%, 0,109 à 2,389 , p-value=0,032< alpha=0,05.

Tableau II : Statistique descriptive des rythmes de base selon les deux méthodes conventionnelle et informatisée

Variables	**Observations**	**Minimum**	**Maximum**	**Moyenne**	**Ecart-type**
Rdb visuel	110	120,000	150,000	134,527	7,763
Rdb calculé	110	118,226	166,669	135,776	9,283

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Le calcul de la moyenne des écarts entre les deux valeurs du rythme de base des deux méthodes selon la procédure décrite par Bland et Altman [7, 8] était de 1,249 bpm, avec un intervalle de confiance à 95%, -10,576 à 13,074. Le graphique de Bland et Altman représentait ces valeurs et permettait l'identification des biais.

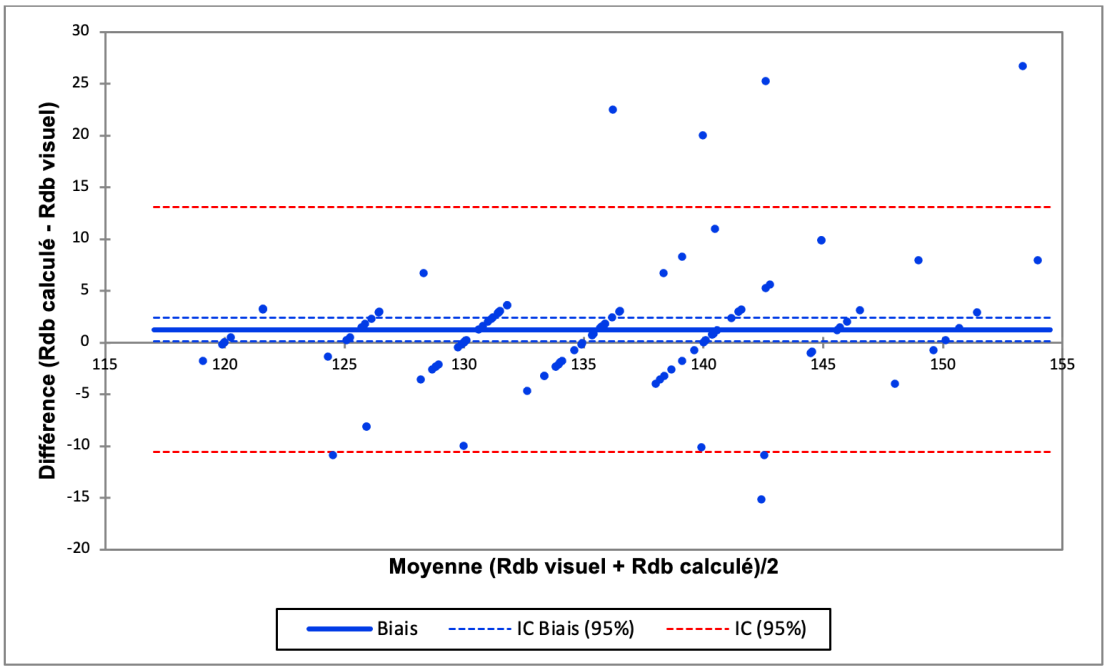

Figure 2 : Graphique de Bland et Altman

4 Discussion

En ce qui concerne la performance médicale, parmi les 110 cas recueillis, nous avons vu que 70,9% du résultat de l'analyse visuelle coïncident avec l'analyse informatisée si nous nous référons à la classification du RCF du CNGOF [6] et que parmi les 29,09% (32 tracés) non concordants 81,25% (26 tracés) sont des tracés normaux après analyse informatisée, de même pour le seul cas pathologique lors de l'analyse visuelle mais qui avait néanmoins une variabilité à long et à court terme douteuse. De plus, 1,81% des cas ont été identifiés comme à risque d'acidose que l'analyse conventionnelle n'a pas pu détecter.

Le coefficient kappa de Cohen égale à 0,564 montre une concordance entre les deux méthodes. A partir de la moyenne des écarts pour les rythmes de base selon la méthode de Bland et Altman nous pouvons dire que le résultat du rythme de base résultant de l'analyse informatisée est valide.

Vu ces résultats on peut dire qu'il y a une concordance entre les deux types d'analyse du RCF. La différence réside probablement sur le fait que l'analyse informatisée est plus précise dans son calcul par rapport à l'œil nu car l'ordinateur scrute pixel par pixel le tracé et réalise le calcul à partir des données captés (précision à10^{-9} près), contre un résultat qui n'est qu'une approximation de ce qui devrait être si nous nous référons à l'analyse conventionnelle.

Selon les études cliniques antérieures par rapport à l'ordinateur, le taux de faux négatifs de l'analyse conventionnelle est de 30 à 35% [8, 9], de plus il existe en analyse subjective un risque de faux positifs à 44% [8].

La réussite de l'analyse informatisée a permis d'interpréter avec exactitude un tracé à partir des résultats de calcul que le logiciel renvoie à l'utilisateur. Les résultats sont affichés avec un pourcentage de

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réussite de 99%, ce qui est largement satisfaisante et aussi encourageante pour une première dans notre pays.

L'impact du logiciel dans la pratique est non négligeable, parce que le système permet de quantifier objectivement les différents paramètres du RCF et même de fournir une reproductibilité des résultats dans le temps et entre observateurs [9]. En effet, lors d'une analyse conventionnelle une grande variation inter et intra-individuelle est souvent observée malgré les différents scores semi-quantitatifs qui existent [10, 11].

L'analyse informatisée du RCF permet de standardiser l'interprétation d'un enregistrement par la quantification des variables, de constituer une aide objective à la décision, de comparer les paramètres du bien-être fœtal jour après jour, de permettre le stockage des enregistrements sur tout support, de constituer une trace écrite quantifiée dont la valeur médico-légale ne peut être ignorée, donc d'éviter les interventions inutiles et permettra d'établir des protocoles de prise en charge dans la surveillance des grossesses à risque et la surveillance du travail.

Selon la littérature, par rapport à l'analyse visuelle, le système informatique diminue la répétition des tracés et qu'on a moins de recours aux différents actes de surveillance fœtale, comme les scores biophysique échographiques [8, 12].

Ainsi le système informatisé permet de confirmer, d'infirmer et de rectifier une interprétation conventionnelle avec précision. En effet la supériorité du système réside dans les tracés suspects et/ou anormaux [8, 10]. La mise en place du système est donc très encourageante et prometteuse pour une première expérience dans notre pays.

Concernant le critère de choix de MatLab, c'est sa disponibilité sur le web en format téléchargeable et sa licence libre. Par rapport aux autres langages de programmation disponibles, il est le plus utilisé en matière de traitement et d'analyse de données représentées en courbe. De plus, il intègre à la fois un module de traitement d'image, des modules de programmation en langage interprété et des outils de création d'interface facilitant ainsi la réalisation d'un projet en utilisant qu'un seul langage. Son efficacité est déjà prouvée dans plusieurs domaines comme dans le domaine de l'ingénierie, de l'économie, etc. Mais jusqu'à maintenant, aucun projet de télémédecine n'a été réalisé avec MatLab à notre connaissance. Or, MatLab ne dispose pas encore de module permettant d'intégrer à la fois le partage des images et le résultat de l'analyse de chaque image. Le logiciel Microsoft Excel a été utilisé à cet effet, l'avantage de cette solution est la possibilité d'enregistrer et de consulter le résultat d'un tracé en format «. XLS ».

Par contre, avec cette solution il s'avère difficile de gérer à la fois les fichiers images analysés et les fichiers Excel résultant de l'analyse. En effet, lors de l'enregistrement du résultat de l'analyse, le fichier image ne sera pas intégré dans le fichier Excel qui contient le résultat de l'interprétation correspondante. L'opérateur aura aussi des difficultés lors de la consultation et le partage des données car il sera confronté à des dizaines voire des centaines de fichiers. La solution à ces défauts est de créer une base de données relationnelle toujours avec MatLab malgré la difficulté de la tâche. Grâce à cette solution, tout fichier image et le résultat correspondant seront enregistrés dans une même base facilitant ainsi la gestion des données. Le système de gestion de base de données utilisé est toujours Microsoft Excel.

Différents systèmes pour la lecture automatisée du RCF ont été développés depuis l977, tous les travaux provenaient exclusivement des travaux mis au point par le Pr Dawes et par Redman à l'université d'Oxford [1, 13]. De même, dans notre recherche les mêmes règles de calcul des différents paramètres ont été reprises pour l'élaboration de l'algorithme de chaque paramètre. Ces différents systèmes sont actuellement utilisés en Obstétrique dans les pays qui ont les moyens technique et financier, tandis que d'autres sont encore au niveau de la recherche comme notre cas.

Par rapport au système Sonicaid Oxford 8000 et 8002 [1, 2], le nombre de cas que nous avons recruté est considérablement insuffisant, mais vu que nous sommes encore en phase de recherche l'objectif d'avoir le maximum de base était donc priorisé. Toutefois, les deux systèmes ont le même mode de calcul des paramètres, et que dans son interface notre système affiche avec le résultat du calcul, l'interprétation, les étiologies éventuelles de chaque résultat de chaque paramètre. L'atout de notre système réside sur le fait que pour les appareils qui n'ont pas de système de lecture automatisé intégré, on peut y avoir recours malgré que l'enregistrement et le résultat de l'analyse soient non synchronisés.

Le système STAN analyse le segment ST. En effet, il utilise le signal capté par une électrode spiralée posée sur le scalp du fœtus. Pour ce système un petit décalage de ST indique qu'il y a risque

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d'acidose [3, 4]. Dans notre étude, faute de moyens technique et financier le segment ST n'est pas pris en compte dans l'analyse d'un enregistrement.

Concernant le système Sisporto, sa particularité est qu'il intègre à la fois l'analyse cardiotocographique et celle du segment ST d'un électrocardiogramme [5]. Quant au résultat, « 2ARCF système » renvoie le résultat des mêmes paramètres que Sisporto et intègre aussi des codes couleur concordant à la classification de tracé du CNGOF. Pour « 2ARCF système » les résultats sont plus descriptifs et que l'analyse est asynchrone. En effet le système calcule et interprète à la fois le résultat trouvé : comme pour la quantification des accélérations et décélérations le logiciel affiche à la fois le nombre, le type et les étiologies éventuelles de ces paramètres.

5 Conclusion

La médecine doit s'adapter, s'intégrer aux nouvelles technologies de l'information et de la communication. A Madagascar, l'informatique médicale représente une solution irréfutable pour l'amélioration et le renforcement de la prise en charge et l'accès aux soins des régions géographiquement éloignés. L'Obstétrique est l'une des spécialités dont l'informatique médicale opère, surtout dans les pays développés, notamment dans la surveillance des grossesses à haut risque par la lecture informatisée du RCF. Dans ce domaine, plusieurs systèmes ont été déjà élaborés et appliqués, malheureusement les moyens financiers et techniques pour acquérir ces logiciels de haute technologie sont hors de portée. C'est une des raisons de l'idée de développer un logiciel qui peut avoir la même performance et la même fonctionnalité mais avec nos propres ressources et qui s'adapte à la situation (technique et financière) actuelle de Madagascar : le « 2ARCF Système ». La fiabilité et la performance du logiciel ont été vérifiées bien que des améliorations techniques et fonctionnelles devront être apportées progressivement.

References bibliographiques

[1] Economides DL, Selinger M, Ferguson J, Bowell PJ, Dawes GS, Mackenzie IZ. Computerized measurement of heart rate variation in fetal anemia caused by rhesus alloimmunization. Am J Obstet Gynecol. 1992; 167: 689-93.

[2] Ribbert LS, Snijders RJ, Nicolaides KH, Visser GH. Relation of fetal blood gases and data from computer-assisted analysis of fetal heart rate patterns in small for gestation fetuses. Br J Obstet Gynecol. 1991; 98: 820-3.

[3] Westgate J, Harris M, Curnow JSH, Greene KR. Plymouth randomized trial of cardiotocogram only versus ST weveform plus cardiotocogram for intrapartum monitoring in 2400 cases. Am J Obstet Gynecol. 1993; 169: 1151-60.

[4] Strachan B, Sahota D, van Wijngaarden WJ, James DK, Chang AZM. The fetal electrocardiogram: relationship with acidemia delivery. Am J Obstet Gynecol. 2000; 182: 603-6.

[5] Ayres-de-Campos D, Sousa P, Costa A, Bernardes J. Omniview-SisPorto 3.5a central fetal monitoring station with online alerts based on computerised cardiotocogram + ST event analysis. J Perinat Med. 2008; 36:260–4.

[6] Recommandations pour la pratique clinique du CNGOF : modalités de surveillance fœtale pendant le travail. http://www.cngof.asso.fr/D.TELE/rpc.surv-foet.2007.pdf

[7] Journois D. Comparaison de deux variables : l'approche graphique (Méthode de Bland et Altman). Rev Mal Respir. 2004; 21: 127-30.

[8] Hiett AK, Devoe LD, Youssef A, Gardner P, Black M. A comparison of visual and automated methods of analyzing fetal heart rate tests. Am J Obstet Gynecol. 1993; 168: 1517-21.

[9] Gagnon R, Campbell MK, Hunse C. A comparison between visual and computer analysis of antepartum fetal heart rate tracings. Am J Obstet Gynecol. 1993; 168: 842-7.

[10] Flynn AM, Kelly J, Matthews K, O'Conor M, Viegas O. Predictive value of, and observer variability in, several ways of reporting antepartum cardiotocograph. Br J Obstet Gynecol. 1982; 89: 434-40.

[11] Lotgering FK, Wallenburg HCS, Schouten HJA. Interobserver and intraobserver variation in the assessment of antepartum cardiotocogram. Am J Obstet Gynecol. 1992; 144: 701-5.

[12] Bracero LA, Morgan S, Byrne DW. Comparison of visual and computerized interpretation of nonstress test results in a randomized controlled trial. Am J Obstet Gynecol. 1999; 181: 1254-8.

[13] Dawes GS, Visser GH, Goodman JD, Levine DH. Numerical analysis of the human fetal heart rate: modulation by breathing and movement. Am J Obstet Gynecol. 1981; 140: 535-44.

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FIGURES

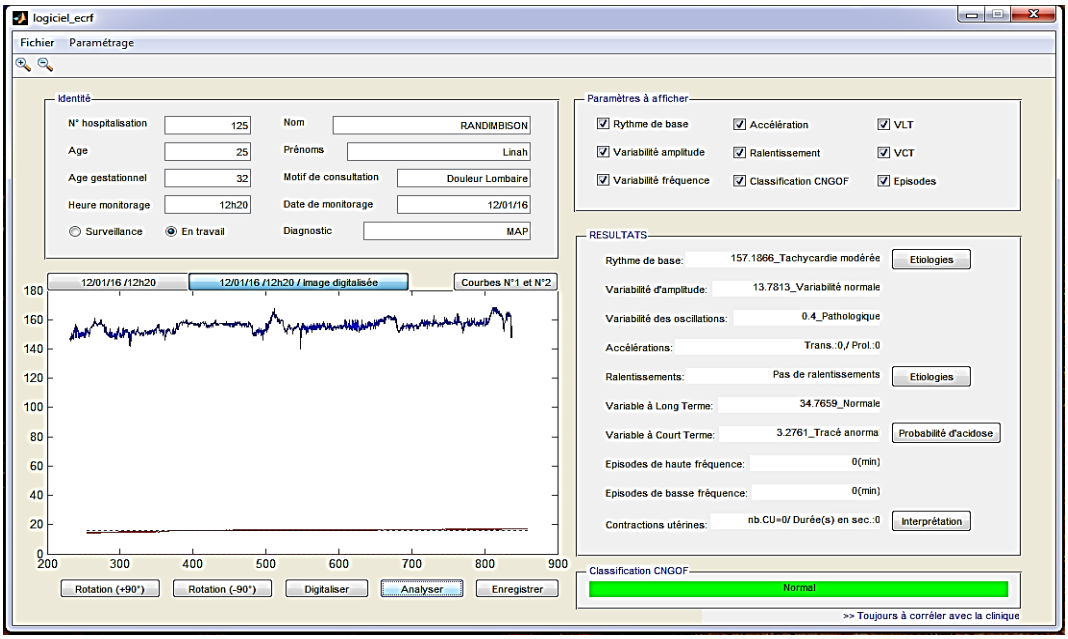

Figure 1 : Interface du logiciel « 2ARCF système ».

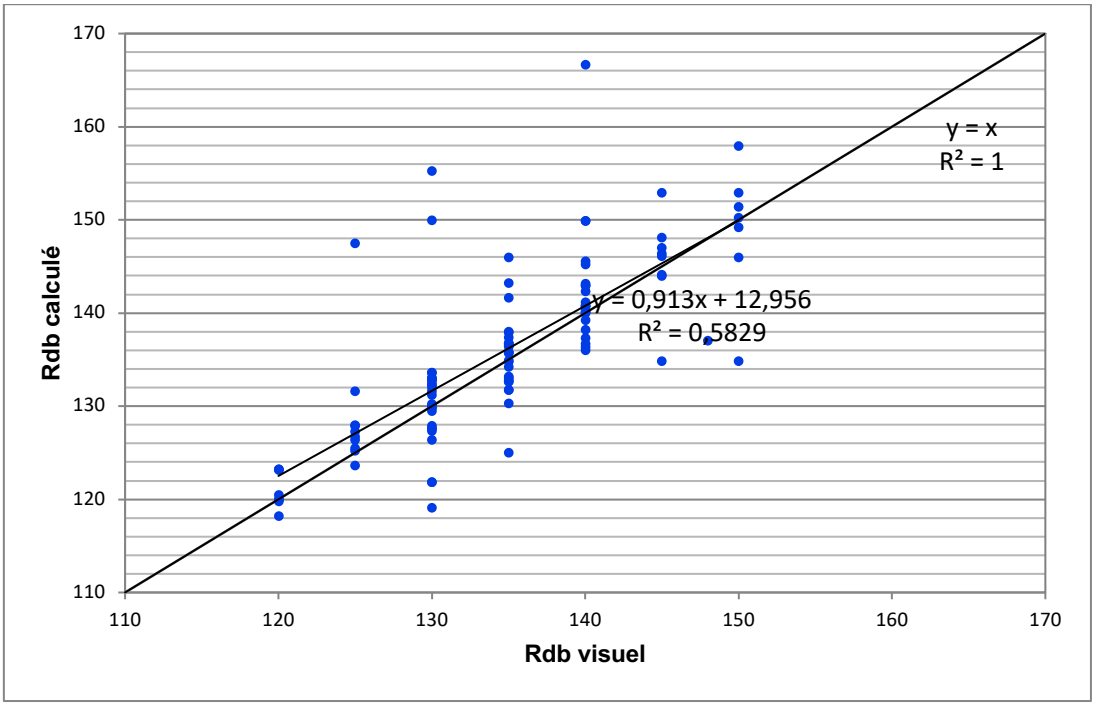

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Figure 2 : Reproduction du rythme de base dans un plan cartésien

UNITES DE MESURE

mn = minute
ms = milliseconde
s = seconde

ABBREVIATIONS

LARTIC= Laboratoire d'Appui aux Recherches et Technologies de l'Information et de Communication
RCF = rythme cardiaque fœtal
CHU = centre hospitalier universitaire
MatLab = Matrix Laboratory
VLT = variabilité à long terme
VCT = variabilité à court terme
SA = semaines d'aménorrhée
Rdb = rythme de base
Bpm = battements par minute
min = minimum
max = maximum
CNGOF = Collège National des Gynécologues- Obstétriciens Français
INEB = Institut National d'Ingénierie Biomédicale

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