


Assessing the efficient use of the lightwave health information management system for health service delivery in Ghana

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ABSTRACT

Background In achieving the WHO's Universal Health Coverage and the Global Developmental Agenda: Sustainable Development Goal 3 and 9, the Ministry of Health launched a nationwide deployment of the lightwave health information management system (LHIMS) in the Central Region to facilitate health service delivery. This paper assessed the efficient use of the LHIMS among health professionals in the Central Region.

Methods A non-interventional descriptive cross-sectional study design was employed for this research. The study used stratified and simple random sampling for selecting 1126 study respondents from 10 health facilities that use the LHIMS. The respondents included prescribers, nurses, midwives and auxiliary staff. Descriptive statistics (weighted mean) was computed to determine the average weighted score for all the indicators under efficiency. Also, bivariate (χ^2) and multivariate (ordinal logistic regression) analyses were conducted to test the study's hypotheses.

Results Findings revealed that the LHIMS enhanced efficient health service delivery. From the bivariate analysis, external factors; sex, educational qualification, work experience, profession type and computer literacy were associated with the efficient use of the LHIMS. However, training offered prior to the use of the LHIMS, and the duration of training had no association. At the multivariate level, only work experience and computer literacy significantly influenced the efficient use of the LHIMS.

Conclusion The implementation of LHIMS has the potential to significantly improve health service delivery. General computing skills should be offered to system users by the Ministry of Health to improve literacy in the use of computers. Active participation in the use of LHIMS by all relevant healthcare professionals should be encouraged.

INTRODUCTION

The WHO considers health information systems to be one of the six essential building blocks of any health system because they provide reliable information to aid in decision-making throughout the health system.^{1 2} Relatedly, the recent global development agenda also sees health information

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The WHO considers health information systems to be one of the six essential building blocks of any health system because they provide reliable information to aid in decision-making throughout the health system. Despite the benefits of electronic health records (EHRs), there are lower adoption and utilisation rates in lower-middle and low-income countries.

WHAT THIS STUDY ADDS

⇒ A non-interventional descriptive cross-sectional study design was employed for this research. It was revealed that sex, educational qualification and training prior to the use of lightwave health information management system (LHIMS) were not statistically significant to health professionals' use of the LHIMS-EHR. However, their years of work experience and computer efficacy have a significant effect on the efficient use of the system.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ In terms of the educational qualification of health professionals and the effect it has on the usability of the LHIMS, policy-makers will need to ensure that the health professionals they engage at their facilities have the required educational qualifications to work and use the LHIMS at the facility. Also, in terms of computer efficacy, policy-makers need to ensure that the health professionals they engage at their facilities have some level of computing knowledge.

systems as one of the critical health delivery components that contribute to achieving goal 3 (good health and well-being) and goal 9 (industry, innovation and infrastructure) of the Sustainable Development Goals.³⁻⁶

In Africa, medical information recording has evolved over the years; from the period of cave recordings, where records were stored on tablets of stone to an age where the paper system was introduced.⁷ Until the latter part of the 20th century, a paper-based record

management system was the primary method of storing health records and other documents.⁸ Although it can be tailored to the needs of each hospital and health-care provider without requiring any technical changes, the introduction of the electronic health record (EHR) system has made paper-based records less effective in healthcare delivery. The limitations associated with the use of the paper-based system now make the EHR system the appropriate option.^{9–11}

Even though EHR systems have evolved into a viable option, there are major drawbacks to their implementation in Africa. For instance, there are lower adoption and utilisation rates in lower-middle and low-income countries.^{12–13} The implemented EHR systems in Africa focus on only a few health conditions such as HIV care, home-based care, injury surveillance, tertiary care, and maternal and reproductive health.^{14–17}

To improve healthcare quality and accelerate the health service delivery processes in Ghana, the Ministry of Health (MoH) published the Health Sector Information and Communication Technology (ICT) Policy and Strategy charts in 2005. It was guided by the Ghana ICT for Accelerated Development policy to increase the adoption of ICT in the health sector.¹⁸ Due to this, some health facilities implemented an EMR system meant for solo practice. The health facilities that used the EMR systems have frequently changed systems due to challenges such as poor report generation, the inability of the system to mimic the daily transactions performed during service delivery (work domain saturation) and clinicians' inability to type on a keyboard while attending to patients. Even though the information generated by the EMR could be shared across departments within one health facility, it was not able to share patient information across multiple providers. As a result of the challenge, some facilities used the system together with paper records as they couldn't fully implement a paperless system.

Due to these challenges, the MoH developed a new policy document in 2009 to aid in the implementation of a national EHR system, a common platform to be used by all health professionals in health facilities across the country. This new implementation was expected to streamline admission, discharge and transfer processes, and be integrated into the claims management system of the National Health Insurance Scheme for billing.¹⁹

Lightwave health information management system (LHIMS) is a web-based software platform that is capable of transmitting health information for use by authorised health service providers and supporting administrative functions such as managing records, making clinical orders, inputting information, storing and retrieval to assist in decision-making during and after the time of care in Ghana.²⁰ It is a comprehensive system with several components including National Health Insurance Authority (NHIA) claims, patient records, administrator, antenatal care, laboratory management, alerts and communication, appointment and scheduling, and radiology. The implementation of LHIMS started in 2017

in the Central Region of Ghana. Adoption is still in the early stages, and it is only about 10% of healthcare facilities have adopted the use of LHIMS.

It has been theorised by Davis²¹ in the Technology Acceptance Model that external factors such as age, gender, organisational factors, etc influence the perceived usefulness of EHR Systems. Also, Al-Rayes *et al.*²² hypothesised that physicians' use of the EHR system is significantly influenced by their age, work experience and medical specialty. This paper, therefore, assesses health professionals' capacity to use LHIMS-EHR efficiently for health service delivery in Ghana.

MATERIALS AND METHODS

Study design

A non-interventional descriptive cross-sectional study design was employed for this research. The population for the study was all the health professionals in the Central Region of Ghana. However, the accessible population was limited to only the health professionals practising at the facilities using the LHIMS for service delivery in the Central Region of Ghana. The reason for targeting this section of health professionals only is that they have been practising with the LHIMS for service delivery at their various health facilities and, it is assumed that these health professionals will have the requisite knowledge of the LHIMS and that they will be able to provide the resourceful knowledge the study seeks to unravel about the LHIMS. In the early stages of implementation, some facilities stopped using the LHIMS because they faced challenges and eventually stopped using it. Other health facilities changed to alternative EHRs.

Sampling technique

A sample size formula was used to estimate 1126 sample size for the survey. A stratified probability sampling approach was used.

Data analysis

Weights of 1, 2, 3, 4 and 5 were assigned to all the 5-point likert scale; strongly disagree (SD), disagree (D), neutral (N), agree (A) and strongly agree (SA), respectively. The weighted mean formula from Manyange and Abuga²³ was employed to compute the weighted average (WA) scores. The weighted mean formula²⁴ was employed to compute the WA scores. The formula is mathematically written as $WA = \frac{\sum wx}{\sum w}$, where w represents the weights and x represents the values. After the computation, the WA scores were interpreted based on the following parameters; 1.0–1.79=SD; 1.80–2.59=D; 2.60–3.39=N; 3.40–4.19=A; 4.20–5.00=SA.

For the bivariate and multivariate analysis, principal component analysis was used as a dimension reduction technique to obtain a factor score for the dependent variable (efficiency). In IBM Statistical Package for the Social Sciences, the result was further examined using the orthogonal rotation approach (Varimax). The

Table 1 Descriptive statistical analysis of the efficient use of LHIMS by respondents

Statement	SD	D	N	A	SA	Weighted average	Interpretation
	1	2	3	4	5		
I can use the LHIMS without written instructions	47	135	247	574	123	3.52	Agree
Using the LHIMS helps me provide the appropriate service for the patient	52	169	267	501	137	3.45	Agree
It is easy to get the LHIMS to do what I want it to do	29	98	206	595	198	3.74	Agree
I can complete a task quickly using the LHIMS	28	76	227	584	211	3.78	Agree
Interaction with the LHIMS requires less mental effort	22	75	216	616	197	3.79	Agree
Learning to operate the LHIMS was easy for me	31	116	253	549	177	3.64	Agree
LHIMS requires fewer steps possible to accomplish a task	38	132	247	562	147	3.58	Agree
I am familiar with the items on the screen of the LHIMS	42	124	217	581	162	3.62	Agree
An increased time is required to enter patient information	37	137	213	561	178	3.63	Agree
LHIMS is simple to use	28	106	213	598	181	3.71	Agree
I can recover from mistakes quickly and easily when using the LHIMS	22	54	252	611	187	3.79	Agree
Using the LHIMS gives me more control to handle patient treatment/service on time	33	105	229	583	176	3.68	Agree
Using the LHIMS reduces the time spent by a client at the Unit	61	149	209	519	188	3.55	Agree

Source: Agyemang, 2021.
 Weighted average = $\sum wx / \sum w$.
 Interpretation: 1.0–1.79=SD; 1.80–2.59=D; 2.60–3.39=N; 3.40–4.19=A; 4.20–5.00=SA.
 A, agree; D, disagree; LHIMS, lightwave health information management system; N, neutral; SA, strongly agree; SD, strongly disagree.

Kaiser-Meyer-Olkin measure of sampling adequacy was greater than 0.5 for all measured constructs. Bartlett's sphericity test was significant ($p=0.05$), and the construct's eigenvalue was greater than 1, accounting for more than 50% of the variance in every construct with individual item loads greater than 0.4.

The study further employed Brooke's (1986) System Usability Scale to categorise the dependent variables to make the factor score reflect a natural setting. Respondents with a factor score of less than 30% were categorised as 'low', those with scores above 30% but not more than 70% were defined as 'moderate', and those with a score of more than 70% were classified as 'high'. This categorisation made it possible to run a χ^2 test for the bivariate analysis and ordinal logistic regression analysis for the multivariate using the proportion of odds (OR) to interpret the differences in the use of LHIMS.

RESULTS

Descriptive statistics of respondents' efficient use of LHIMS

The questions in the descriptive analysis were adapted from the Computer System Usability Questionnaire designed by International Business Machines (IBM) and the Isometric questionnaires.

Table 1 shows the descriptive statistical analysis of the efficient use of the LHIMS for health service delivery by respondents in the Central Region. In order to determine the average weighted score for all of the indicators under efficiency, a 5-point Likert scale ranging from SD,

D, N, A and SA were assigned weights of 1, 2, 3, 4 and 5, respectively.

Bivariate analysis of sociodemographic characteristics and efficient use of LHIMS

In table 2, a χ^2 test of independence was performed to examine the relationship between respondents' sex, age, educational qualification and years of work experience and the efficient use of LHIMS.

Professional characteristics and efficient use of LHIMS

Kaipio *et al*²⁵ postulate that there are significant differences between nurses' and physicians' experiences of the usability of EHR systems. Consequently, in table 3, a χ^2 test of independence was conducted to examine the relationship between the respondents' professional type and the institution where the professional was trained (training institution) and the efficient use of LHIMS.

Training and computer efficacy and the efficient use of LHIMS

In table 4, a χ^2 test of independence was conducted to assess the association between respondents' training status prior to the use of the LHIMS, duration of the training and computer efficacy and the efficient use of LHIMS.

Multivariate analysis of the efficient use of LHIMS by respondents

In table 5, multivariate analysis was performed to assess the influence of sociodemographic characteristics of

Table 2 Bivariate (cross-tabulation) analysis of sociodemographic characteristics and efficient use of LHIMS by respondents

Variable	Efficiency			P value
	Inefficient	Moderately efficient	Highly efficient	
Sex	Freq. (%)	Freq. (%)	Freq. (%)	
Female	186 (26.9)	282 (40.8)	223 (32.3)	0.022
Male	148 (34.0)	172 (39.5)	115 (26.4)	
Age				
20–29	160 (30.0)	225 (42.20)	148 (27.80)	0.610
30–39	148 (29.20)	196 (38.70)	163 (32.10)	
≥40	26 (30.20)	33 (38.40)	27 (31.40)	
Educational qualification				
Certificate holder	43 (33.1)	51 (39.2)	36 (27.7)	0.004
Diploma/Higher National Diploma	125 (27.4)	166 (36.3)	166 (36.3)	
Degree	166 (30.8)	237 (44.0)	136 (25.2)	
Years of work experience				
≤1 year	120 (32.8)	148 (40.4)	98 (26.8)	0.040
2–5 years	157 (30.0)	215 (41.1)	151 (28.9)	
≥6 years	57 (24.1)	91 (38.4)	89 (37.6)	

Source: Agyemang, 2021.
LHIMS, lightwave health information management system.

respondents (age, sex, educational qualification and years of work experience), professional characteristics (professional type, place of training and institution of training) and training/computer efficacy (training status, duration of training and computer efficacy) on the efficient use of the LHIMS. In model 1, ordinal logistic regression analysis was fitted to assess the relationship between respondents' sociodemographic characteristics (age, sex, educational qualification and years of work experience) on the efficient use of the LHIMS. In model 2, controlling for sex, educational qualification and years of work experience of respondents, ordinal logistic regression was fitted to assess professionals' characteristics (professional type and training institution the respondent attended). In

model 3, accounting for sex, educational qualification, work experience and training of professionals prior to EHR use, ordinal logistic regression was fitted to assess computer efficacy and the efficient use of the LHIMS.

DISCUSSION

According to the MoH,²⁶ it is becoming increasingly evident that many developing countries, including Ghana, would struggle to meet all the global targets required to improve their health sector. As a result, a national e-health system, the LHIMS, was necessary for the health sector to improve service efficiency and function as the country's EHR and a biosurveillance system.²⁶

Table 3 Bivariate (cross-tabulation) analysis of professional characteristics and efficient use of LHIMS by respondents

Variable	Efficiency			P value
	Inefficient	Moderately efficient	Highly efficient	
Professional type	Freq. (%)	Freq. (%)	Freq. (%)	
Prescribers	86 (34.0)	116 (45.8)	51 (20.2)	0.003
Nurses and midwives	212 (29.0)	281 (38.4)	239 (32.7)	
Auxiliary	36 (25.5)	57 (40.4)	48 (34.0)	
Training institution				
MOH training institution (NMTC, CoH, community)	187 (29.7)	261 (41.5)	181 (28.8)	0.543
University	147 (29.6)	193 (38.8)	157 (31.6)	

Source: Agyemang, 2021.
LHIMS, lightwave health information management system; MoH, Ministry of Health.

Table 4 Bivariate (cross-tabulation) analysis of training/computer efficacy and LHIMS efficiency for health service delivery by respondents

Variable	Efficiency			P value
	Inefficient	Moderately efficient	Highly efficient	
Training	Freq. (%)	Freq. (%)	Freq. (%)	
Yes	303 (30.2)	414 (41.2)	287 (28.6)	0.011
No	31 (25.4)	40 (32.8)	51 (41.8)	
Duration of training				
Never trained	34 (27.9)	55 (45.1)	33 (27.0)	0.263
1–2 days	178 (28.6)	248 (39.9)	196 (31.5)	
3–4 days	66 (36.9)	62 (34.6)	51 (28.5)	
5 days or more	56 (27.6)	89 (43.8)	58 (28.6)	
Computer efficacy				
Beginners	83 (34.6)	112 (46.7)	45 (18.8)	0.000
Advanced users	251 (28.3)	342 (38.6)	293 (33.1)	

Source: Agyemang, 2021.
LHIMS, lightweight health information management system.

Table 5 Ordinal logistic regression analysis of sociodemographics, professional characteristics and training/skill on the efficient use of LHIMS by respondents

Variable	Model 1	Model 2	Model 3
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Sociodemographic			
Sex			
Female	1.286 (1.021 to 1.62)*	1.276 (1.013 to 1.609)*	1.199 (0.947 to 1.518)
Male	1.00	1.00	1.00
Educational qualification			
Certificate	0.96 (0.67 to 1.374)	0.92 (0.641 to 1.321)	0.879 (0.611 to 1.265)
Diploma/Higher National Diploma (HND)	1.336 (1.052 to 1.698)*	1.288 (1.01 to 1.641)*	1.245 (0.976 to 1.589)
Degree+	1.00	1.00	1.00
Work experience			
≤1 year	0.621 (0.458 to 0.842)*	0.622 (0.458 to 0.844)*	0.628 (0.462 to 0.852)*
2–5 years	0.714 (0.537 to 0.95)*	0.721 (0.541 to 0.96)*	0.724 (0.544 to 0.965)*
≥6 years	1.00	1.00	1.00
Training/skill			
Status of training			
Yes		0.691 (0.48 to 0.994)*	0.715 (0.496 to 1.031)
No		1.00	1.00
Computer efficacy			
Beginner			0.689 (0.525 to 0.904)*
Advanced users			1.00

Source: Agyemang, 2021.
1.00=reference category; sample (N)=1126.
p<0.05.
LHIMS, lightweight health information management system.

Findings from the study revealed that the LHIMS enhances service delivery efficiency. The health professionals who participated in the study indicated that using the LHIMS lessens a patient's time spent at the unit and facilitated quick task execution, as well as assists in giving the patients the proper care. Admittedly, these results are consistent with the 2005 and 2010 National E-Health Strategy Policy's objective²⁷ and with the international standard, HealthIT.Gov²⁸ which suggests that an EHR system should offer quick access to patient records and efficient job execution in addition to providing accurate, full and up-to-date patient information at the point of care. The findings show that the LHIMS has these features and is now deployed and used widely within the health sector of Ghana. However, results from Hodgson *et al.*²⁹ research reported inefficiencies of EHRs adoption such as system users being permanently connected to a computer and using multiclick diagnostic chart navigations which make the use of EHR systems by health professionals undesirable. However, the findings from our study indicated the contrary. The reasons that might account for the differences in literature may be due to several factors including, the type of EHR software deployed, the design of the system interface, personal factors such as age, sex, work experience, training prior to system use and type of profession.³⁰ For instance, Shanafelt *et al.*³⁰ argue that several factors influence the efficient use of EHR systems. According to the technology acceptance model by Davis,²¹ external factors such as age, gender and organisational factors are theorised to influence the perceived usefulness (efficiency) of an EHR system. As a result, this current study hypothesised that health professional's efficient use of the LHIMS is influenced by sociodemographic characteristics (age, sex, educational qualification and years of work experience), professional characteristics (staff category, place of training and institution of training) and computer self-efficacy. The results of the multivariate analysis for sociodemographic characteristics (age, sex, educational qualification and years of work experience) of health professionals and the efficient use of EHRs revealed that age, sex and educational qualification had an insignificant effect on the efficient use of EHR. However, years of work experience were the only sociodemographic characteristic that was found to have a statistically significant influence on the efficient use of LHIMS. The results agree with the findings from Adedeji *et al.*,³¹ Khairat *et al.*³² and Bae and Encinosa.³³ Adedeji *et al.* in their study found a significant association between the use of EHR and age, availability of computer systems, years of working experience and training of users.³¹ The results of their study are in contrast with that found in this study except in terms of years of work experience which was found to have no significant effect on efficiency in the use of EHR among health professionals.³¹ Khairat *et al.* in their study examined how doctors' performance, efficiency, perceived workload, happiness and usability of the EHR differed depending on their age, gender, professional function and years of experience with the EHR.³²

They found some differences in efficiency among male and female physicians.³² The data showed that female physicians are more efficient in using EHRs as they used the EHR's general search bar and filters, which resulted in a more efficient search, and this means that differences in sex among health professionals play a role in their efficient use of EHR.³² This finding contrasts with the one obtained in this study. However, even though sex, in general, was found to have no significant effect on the efficient use of EHR, the results, show that females in practice will be able to use the LHIMS-EHR more efficiently as compared with their male colleagues. This somewhat contrasting analysis may be due to the bivariate analysis which showed that the sex of health professionals has an association with their efficient use of EHR.

Bae and Encinosa³³ in their study revealed that age and years of work experience matter in the efficient use of an EHR system.³³ They found that older physicians who have more years of experience in the field were better at integrating EHR into clinical practice as compared with younger physicians with just a few years of work experience.³³ Their study, therefore, provides support for the finding that years of work experience have played a major role in the efficient use of LHIMS by health professionals but contrasts with the finding that the age of health professionals does not affect how efficiently they use EHR. These findings indicate that not all external factors (age, sex and education) in the technology acceptance model by Davis²¹ may predict differences in the efficient use of the LHIMS and the variation in the literature is dependent on the type of EHR software adopted.

Aside from social demographic characteristics, the multivariate analysis of professional characteristics and efficient use of the LHIMS revealed an insignificant association between professional type and the institution where health professionals receive their training and efficient use of the LHIMS. However, the bivariate analysis of professional type and efficiency in the use of the LHIMS showed a significant association between the two. This means that the professional characteristics of health professionals do not affect how efficiently respondents used the LHIMS taking into consideration other variables such as age, sex, education and years of work experience. Similar findings are noted in the works of Nandikove *et al.*³⁴ The researchers indicated no significant differences among professional types concerning the use of the EHR system in Kakamega County, Kenya.³⁴

The multivariate analysis of training/computer efficacy showed that computer efficacy had a significant effect on the efficient use of LHIMS whereas training was found to have no significant effect. This means that health professionals cannot use the LHIMS efficiently without computer efficacy. However, whether they receive training on using EHR systems does not greatly enhance their efficiency. Contrarily, Butcher found different results on training and professional type.³⁵ According to Butcher, health professionals who received training in EHR systems used relatively less time working in the EHR

systems as compared with when they had not received any training.³⁵

However, the bivariate analysis showed a significant relationship between the two even though the multivariate analysis revealed there is no causal relationship between the two. It can therefore be inferred that even though training does not significantly affect health professionals' efficiency with LHIMS, it can go a long way to improve their proficiency in the use of the system. This may be because health professionals may not be able to use EHR systems most optimally as they may not have received any prior training on EHR systems in their training institutions. It may also be that the training was not effective since most respondents received just a day of training and some did not receive training at all but relied on their colleagues for support in using the LHIMS. Both situations necessitate training specific to the EHR system being used at their health facility for improved proficiency.

The results of the study pertaining to service delivery efficiency revealed that sociodemographic characteristics and the computer efficacy of health professionals are very important factors if they are to use the LHIMS efficiently. This implies that hospital governing bodies and health administrators will need to make sure that all health professionals that will be posted or hired have taken some general computing courses as, without it, efficient use of the LHIMS at the facility level will be significantly affected. Also, the MoH and its Agencies including hospital managers need to ensure that new entrant of health professionals with little or no work experience are to be trained and paired with experienced system users of the LHIMS. This is to ensure that the inefficiencies identified with the use of EHR systems by other researchers will not be experienced at the centre as they have serious repercussions for patients as well as the institution.

CONCLUSION

It can be implied from the results of descriptive statistics, LHIMS deployment has enhanced service efficiency. The bivariate analysis revealed that there is an association between training prior to the use of the LHIMS and the efficient use of the system. However, at the multivariate level, training prior to the use of LHIMS was not statistically significant but computer efficacy and years of work experience were statistically significant. This result implies that not only should health professionals be trained on the use of the LHIMS but for professionals to be more efficient in the use of the LHIMS, they should be trained in general computing skills to improve their computer efficacy. Also, findings imply that health professionals with more work experience need to support their colleagues with little work experience in using the LHIMS to enhance the overall efficiency of the institution. Also, aside from the general training given to all the health professionals at a health facility, health professionals can seek individualised IT training based on their professional type and information needs for optimum proficiency in

the use of the LHIMS by way of increased confidence in all healthcare activities and overall time reduction in the system among health professionals.

Contributors EA, KE-D, ABA-G and EKA were responsible for the conception and design of the study. EA was responsible for the conception and design of the survey questions, and the acquisition, and interpretation of data. EA conducted statistical analyses and drafted tables, and figures. EKA wrote the original manuscript of the paper. EA, KE-D, ABA-G, EKA, POA and JBD reviewed and edited the manuscript. The final version of the manuscript was approved by all contributing authors. EKA is the guarantor for this study.

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