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ORIGINAL RESEARCH

The Applicability of the Modified Technology Acceptance Model (TAM) on the Sustainable Adoption of eHealth Systems in Resource-Limited Settings

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Mulugeta Hayelom Kalayou
Berhanu Fikadie Endehabtu
Binyam Tilahun

Department of Health Informatics, Institute of Public Health, College of Medicine and Health Sciences, University of Gondar, Gondar, Ethiopia

Background: The implementation of eHealth systems with a trial-and-error approach is very expensive and unsuccessful. So, this study aims to examine the constructs and relationships of the modified technology acceptance model (TAM) to determine whether it can be applied to assess health professional's behavioral intention to adopt eHealth systems in resource-limited settings or not.

Methods: The institutional-based cross-sectional study design was conducted among a total of 384 healthcare professionals in referral hospitals of Amhara regional state, Ethiopia. Self-administered questionnaire was used to collect the data, and the data were entered using Epi-info version 7 and the descriptive data were analyzed using SPSS version 25. Structural equation modeling, using AMOS 22, was also applied to describe and validate the degree of relationships between variables.

Results: The findings of the structural equation modeling (SEM) indicate that perceived usefulness has a significant influence on attitude (β =0.298, P<0.01) and intention to use eHealth (β =0.387, P<0.01). Perceived ease of use has significant influence on perceived usefulness (β=0.385, P<0.05) and attitude (β=0.347, P<0.05) and intention to use eHealth (β=0.339, P<0.01). Technical infrastructure has significant influence on attitude (β =0.412, P<0.01) and intention to use eHealth (β =0.355, P<0.01). The staffs IT experience has a significant influence on perceived usefulness (β =0.595, P<0.01) and attitude (β =0.267, P<0.05), but the effect of IT experience on the intention to use eHealth was not significant. Among all the constructs, healthcare professionals attitude towards eHealth showed the strongest effect on the intention to use eHealth systems (β = 0.52, P<0.01).

Conclusion: Overall, this model describes 56.2% of the variance in behavioral intention to use eHealth systems. Therefore, the implementers should give priority in enhancing the organizations technical infrastructure, staff's IT skill, and their attitude towards eHealth by giving continuous support.

Keywords: electronic health, medical records systems, TAM, computerized health systems

Correspondence: Mulugeta Hayelom Kalayou
Department of Health Informatics, Institute of Public Health, College of Medicine and Health Sciences, University of Gondar, Gondar, Ethiopia
Tel +251919047069
Email Mhayelom5@gmail.com

Introduction

eHealth, defined as use of information and communications technologies (ICT) in support of health and health-related fields, including health-care services, health surveillance, health literature, and health education knowledge and research[1] has potential benefits in providing and supporting the healthcare service by facilitating information sharing and evidence-based health practice.[2,3] Health technology

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applications, like hospital information system (HIS), electronic health record (EHR), mobile health (M-health), decision support system (DSS), electronic medical record system (EMR) and research/data collection systems (RCS) have a big value in different settings of the healthcare by reducing healthcare costs, advancing access for up-to-date information, enable quick access for patient records and improve communication between patient and healthcare providers.[4–7]

Over the past decade, the practical implementation and integration of eHealth systems have been scaled drastically. Many developed nations are utilizing eHealth technologies and make a real difference in improving patient care, and the provision of efficient and effective healthcare services.[8–11] As the developed nations in the developing world even though the progress and the success rate are not satisfied there are a trial and deployment of eHealth technology in many sectors of the health arena.[12–16] Un despised changes in documentation practice, patient alerting, teleconsultation and evidence-based practice were showed and a big emphasis from the government side in deploying systems is also increased with a growing need of identifying crucial constructs for the sustainable adoption of eHealth technologies.[14,15]

In Ethiopia, several eHealth technologies had been implemented like SmartCare, mobile ENAT messenger, maternal interactive voice record (IVR) and Health management information system (HMIS). District Health Information System (DHIS2): a tool for collection, validation, analysis, and presentation of aggregate and patient-based statistical data, is also in progress to deploy throughout the country.[17–19] All the previously deployed systems and the systems that are in progress have been implemented using a trial-and-error approach which is very expensive and unsuccessful.[5–7,20] Due to this, the implementation and diffusion of eHealth technology in Ethiopia is still in the embryonic stage.[21–24]

Developing nations like Ethiopia, with limited resources to implement eHealth technology, needs an empirically validated model that supports to identify the main elements of the system implementation and user's behavioral intention to use eHealth technologies that can be used by executives for prior preparation.[22,23] Numerous empirical studies have been conducted in different domains to explore the confusion on the sustainable adoption of technologies.[10,25–31] Technology acceptance model (TAM) is one of the popular and commonly used model to study the social mechanisms of technology adoption, which has been modified from time to time.[25,32] Much smaller researches have been conducted to assess whether TAM elements can be applied to eHealth technology adoption and user acceptance.[33–36] Some studies showed that the main elements of TAM perceived usefulness, perceived ease of use, and attitude towards eHealth technology have a strong impact on a user's intention to use eHealth technology.[9,35,37,38] Besides the main constructs of TAM other external variables like information sharing, the staff's IT experience, and technical infrastructure was found positively significant to the intention of eHealth technology.[28,39] However, there is still inadequate information on how technologies are adopted and used in Healthcare by health professionals, particularly in a resource-limited context.

This study is therefore intended to fill these gaps by assessing the validity of the modified TAM model and by determining the effect of staff IT experience and technical infrastructure on the original TAM constructs among healthcare professionals in a low-resource setting. The main purpose of this study was to:

1. Introduce a modified theoretical model constructed based on the Technology acceptance model (TAM).
2. Empirically test the modified technology acceptance model for determining the key factors influencing the intention of healthcare professionals to adopt eHealth technologies in a resource-limited setting.

Theoretical Background

Technology acceptance model (TAM) is one of the popular models, which helps to model how peoples come to admit and utilize new technologies. The model focuses on factors determining behavioral intention to use new technologies from the end user's perspective.[36,40–42] TAM comprises core variables of user motivation: perceived ease of use, perceived usefulness, and attitudes toward technology. Of these elements, perceived usefulness (PU) and perceived ease of use (PEU) are considered as a principal determinant that directly or indirectly explains the behavioral intention to use ("acceptance") new technology.[29,43–48] In this study, we hypothesized that the constructs and associations described in the modified TAM model are valid to measure the behavioral intention to use eHealth technology by health professionals in low-resource settings. The proposed research variables, their relationships, the research framework, and our hypotheses are explained in Figure 1.

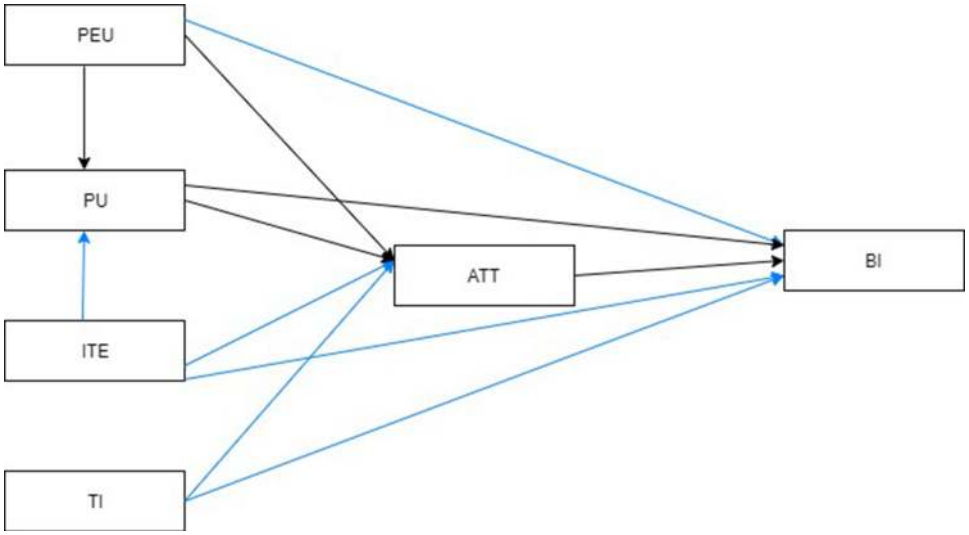

Figure 1 The original model (the black lines), and the modification proposed in this study (the Blue lines).

Perceived Usefulness (PU)

Perceived usefulness refers to "the extent to which an individual believes that applying certain technology will advance job performance".[44] Studies conducted on technology acceptance in different domains have suggested that PU as the main determinant factor for new technology acceptance and use.[30,49–51] Users perception on the usefulness of a technology could be affected by external factors.[34,50,52,53] With respect to this context, this study tests the following premises:

H1: Perceived usefulness will have a positive effect on user's attitude towards eHealth.

H2: Perceived usefulness will have a positive effect on intention to use eHealth.

Users Perceived Ease of Use (PEU)

Perceived ease of use is the extent to which a person believes that a particular technology will be effortless and easy to use.[54,55] PEU is considered as one of the most important constructs of TAM that helps to predict user's acceptance or rejection of technologies.[56–58] Agreeing with the above findings, we would like to extend the hypotheses by testing the following hypotheses:

H3: Perceived ease of use will have a positive effect on Perceived usefulness of eHealth.

H4: Perceived ease of use will have a positive effect on user's attitude towards eHealth.

H5: Perceived ease of use will have a positive effect on intention to use eHealth.

Attitude Towards Using eHealth (ATT)

Attitude is a predisposed state of mind regarding the benefits of a system in improving work performance, time management to conduct their work and its effect in improving the quality of the work they do.[59] Several studies suggest that attitudes of users are a significant factor in the acceptance and efficiency of the use of technologies in practice.[60–63] Findings from different studies show that the Healthcare provider's attitude and acceptance are vital in the success of eHealth system implementation in the healthcare systems since they are the primary users of the system.[20,64–66] With respect to the above findings, this study tests the following hypotheses:

H6: users' attitude towards e-health will positively influence intention to use eHealth.

Staff IT Experience (ITE)

IT experience deals with health professional's knowledge of information technology, understanding the basic benefits of technology and their exposure to it, or taking the training.[67,68] Healthcare providers with a sound level of IT experience were found interactive with, medical information systems, electronic health records, telehealth solutions, and other up-to-date eHealth applications.[65,67–71] Thus, with this background this study tests the following hypotheses:

H7: staff's IT experience will have a positive effect on user's Perceived usefulness of eHealth.

H8: staff's IT experience will have a positive effect on attitude towards eHealth.

H9: staff's IT experience will have a positive effect on intention to use eHealth.

Technical Infrastructure (TI)

TI refers to a set of information technology (IT) components that are the foundation of an IT service in the organization.[72] The technical infrastructure of the organization like the availability of computers to use eHealth systems, the existing infrastructure of the hospital, and the current system that maintains the hospitals existing infrastructure were addressing here. Although technical infrastructure is not one of the TAM constructs, several studies consistently indicate that facilitating conditions influences users' attitude and intention to use technology.[73–79] In this regard, the technical infrastructure is expected as one of the main predictors for the sustainable adoption of eHealth. Therefore, this study tests the following hypotheses:

H10: technical infrastructure will positively influence on attitude towards eHealth.

H11: technical infrastructure will positively influence intention to use eHealth.

Methods

Study Design and Setting

An institutional-based quantitative cross-sectional study design was conducted from April 15 to May 10, 2018, at five referral hospitals (Debre Berhan, Debre Markos, Felege Hiwot, Dessie, and University of Gondar referral Hospitals) of Amhara region, Northern Ethiopia. The hospitals serve more than 30 million population of the region of Amhara and provide referral services for neighborhood regions. All Hospitals had an implementation history of eHealth systems like EMR and e-HMIS, though the systems are functioning in some departments of the hospitals.

Sample Size and Study Participants

All health professionals who were working in the five-referral hospitals of the Amhara region were the source population for this study. The sample size of the study was calculated using a single population proportion formula,[80,81] and by considering all the sample size calculations used for Structural Equation Modeling (SEM) analysis.[82–85] Then, the final sample size was calculated assuming a 95% of confidence level, 5% margin of error, and 10% of non-response rate, which resulted in a participant of 423. Staff who were on annual and sick leave were excluded from the study, and the participants were selected using a simple random sampling technique. Two data collectors were assigned to each hospital.

Instrument Development and Validation

A structured questionnaire was adapted by reviewing several works of literature conducted on the area.[28,48,50,79,86] The structured questionnaire has two categories, the first category encompasses sociodemographic-related questions and the second part contained elements related to TAM constructs (PU, PEU, ATT, and BI) and additional elements ITE and TI with 24 Likert scale items. The questioner was a self-administered questioner and the respondents filled it. The questioner was developed to test the hypotheses. The pretest of the questioner was conducted at another hospital which is other than the study hospitals. Based on the feedback from the respondents, the questions had modified with their wording by language experts. Reliability tests were checked using the Cronbach alpha coefficient (Cα), composite reliability (CR), and standard loading (SD) using structural equation modeling. The results of the three tests demonstrated scores for all the items over the criterion as shown in Table 1. Thus, the indicators measuring the constructs in the present study all carried sufficient item reliability, as shown in the following Table 1.

Data Management and Analysis

Data from respondents were entered using Epi-info version 7 and exported into SPSS version 25 for descriptive data analysis. The extent of the relationship between variables was clarified using AMOS 22 structural equation modeling (SEM). For this reason, SEM was used to test the hypotheses since it is a dominant statistical method that measures and clarifies the degree of relationships between variables. The model's overall goodness of fit was also measured and assessed based on standards from previous studies[87,88] using Chi-square ratio (<3), normal fit index (NFI > 0.9), the goodness of fit index (GFI >0.9), adjusted goodness of fit index (AGFI > 0.8), and root mean square of standardized residual (RMSR <0.08).

Table 1 Evaluation of Reliability Measurement

Variables	Items	SD	CR	AVE	Cα
Perceived usefulness	PU1 PU2 PU3 PU4	0.82 0.79 0.78 0.81	0.84	0.72	0.87
Perceived ease of use	PEU1 PEU2 PEU3 PEU4	0.82 0.86 0.81 0.83	0.78	0.64	0.88
IT experience	ITE1 ITE2 ITE3	0.75 0.78 0.78	0.87	0.86	0.80
Technical infrastructure	TI1 TI2 TI3 TI4	0.83 0.85 0.86 0.83	0.80	0.67	0.90
Attitude towards e-health	ATT1 ATT2 ATT3 ATT4	0.81 0.82 0.80 0.77	0.75	0.61	0.87
Intention to use e-health	BI1 BI2 BI3 BI4 BI5	0.82 0.80 0.78 0.79 0.80	0.84	0.72	0.89

Abbreviations: SD, standard loading; CR, composite reliability; Cα, Cronbach's of alpha α; AVE, average variance extracted; PU, perceived usefulness; PEU, perceived ease of use; ITE, IT experience; TI, technical infrastructure; ATT, attitude; BI, behavioral intention.

Ethics Approval and Consent to Participate

This study was conducted in accordance with the Declaration of Helsinki. Ethical clearance was obtained from the Ethical review board of Institute of Public Health, University of Gondar. Supporting letter was also obtained from Amhara regional state Public Health Research Institute and respective referral hospitals. The objectives and the purpose of the study were presented for the participants at the front page of the questioner. An informed written consent was accepted for this particular study from the study participants. Each study participant had the right of withdrawal from the study at any time during data collection. Due attention was given to not personalize any of the response of the respondents during data presentation, analysis and interpretation.

Result

A total of 423 study subjects were included in the study, 384 (response rate 91%) of them gave their consent, and responded to the questions. From the total of (n=384) respondents, 244 (63.5%) of them were males, and more than half of the respondents 212 (55.2%) had less than or equal to 5 years of work experience, and more than half of the 214 (55.7%) had taken basic computer courses. In addition, the mean age of the respondents was 29.9 years with a standard deviation of ±6.17 years as shown in Table 2.

Validation of the Revised TAM Constructs

The constructs were tested by examining the structural models and are summarized in Table 3, in which the t-statistics and standardized path coefficients (β) are presented. The relationships between the dependent and independent variables are also shown. All hypotheses proposed in this study were found significant, except for H9.

Table 2 Sociodemographic Characteristics of Healthcare Providers in Amhara Regional State Referral Hospitals, Ethiopia (n=384)

Sociodemographic Characteristics	Frequency	Percent (%)
Gender		
Female	140	36.5
Male	244	63.5
Age		
< 30	226	58.9
30–40	126	32.8
> 40	32	8.3
Work experience		
≤5	212	55.2
6–10	82	21.4
10–15	57	14.8
>15	33	8.6
Profession		
Physicians	48	12.5
Nurses	206	53.6
Pharmacist	59	15.4
Lab technologist	39	10.2
Others*	32	8.3
IT course		
No IT course	79	20.6
Basic course	214	55.7
Advanced training	91	23.7

Note: *Physiotherapist, Anesthetists.
Abbreviation: IT, information technology.

Table 3 Results of Structural Equation Modeling in AMOS with the Path Coefficients for All of the Nine Hypotheses

Path	β	t-Statistics	Supported?
Perceived usefulness → Attitude towards e-health (H1)	0.298	4.77**	Yes
Perceived usefulness → Intention to use e-health (H2)	0.387	3.54**	Yes
Perceived ease of use → Perceived usefulness (H3)	0.385	3.11*	Yes
Perceived ease of use → Attitude towards e-health (H4)	0.347	3.91**	Yes
Perceived ease of use → Intention to use e-health (H5)	0.339	2.68*	Yes
Attitude → Intention to use e-health (H6)	0.526	6.66**	Yes
IT experience → Perceived usefulness (H7)	0.595	5.21**	Yes
IT experience → Attitude towards e-health (H8)	0.267	3.69*	Yes
IT experience → Intention to use e-health (H9)	0.062	1.35	No
Technical infrastructure → Attitude towards e-health (H10)	0.412	5.71**	Yes
Technical infrastructure → Intention to use e-health (H11)	0.355	3.71**	Yes

Notes: Goodness of fit $\chi 2/d.f.$ = 1.60, NFI = 0.95, RMSR = 0.040, GFI =0 0.93, AGFI =0 0.88. *p < 0.05, **< 0.01.

The analysis showed perceived usefulness has a significant effect on the intention to use eHealth (β =0.387, P<0.01) and attitude towards eHealth (β =0.298, P<0.01); the organization's technical infrastructure has a significant effect on healthcare providers intention to use eHealth (β =0.355, P<0.01) and their attitude towards eHealth (β =0.412, P<0.01); healthcare providers experience on IT has a strong effect on perceived usefulness (β =0.595, P<0.01) and their attitude towards eHealth (β =0.267, P<0.05); the user's perceived ease of use about the system has a significant effect on perceived usefulness (β =0.385, P<0.05), attitude towards eHealth (β =0.347, P <0.01) and behavioral intention to use eHealth (β =0.339, P<0.05), attitude towards eHealth is also found with a strong effect on the intention to use eHealth (β =0.526, P<0.01).

Perceived usefulness and technical infrastructure exhibited a stronger effect than perceived ease of use on user's attitude and behavioral intention to use eHealth, which implies Perceived Usefulness and Technical Infrastructure are a crucial factor in developing nations' eHealth systems adoption. And Attitude takes the lead in determining people's behavioral intention to use eHealth systems. In terms of goodness of fit indicators, Perceived usefulness, Perceived ease of use, IT experience, and Technical infrastructure accounted for 53.3% and 46.7% of the variance in attitude and BI to use eHealth, respectively, with the exception of IT experience for the second scenario. An Individual's attitude to use eHealth accounted for 44.3% of the variance in Behavioral intention to use eHealth. Generally, the structural model results have elucidated that 56.2% of the variance in behavioral intention to use eHealth systems was explained by these measures.

Discussion

This study was conducted to empirically validate the generalizability of the modified technology acceptance model (TAM) by assessing the constructs of the model in the context of Resource-limited setting hospitals. Additionally, insights were provided into future eHealth implementation success research by assessing the effect of additional factors (staff's IT experience and technical infrastructure of the organization) on the relationship between intention to use and attitude towards eHealth systems. For sustainable adoption of eHealth systems in resource-limited settings, the healthcare providers IT experience and the organizations technical infrastructure were found crucial.

All the hypotheses were checked ether they had a relationship with the outcome variable or not. All constructs, except the effect of the staff's IT experience with the intention to use eHealth (Figure 2), which tests the relationship between the independent variables and the outcome variable were found with a strong positive association. Relationships of perceived usefulness, organization's technical infrastructure, perceived ease of use, user attitude towards eHealth, and intention to use eHealth were proven to possess adequate psychometric properties and thus can be used as effective measures of eHealth adoption in resource-limited settings. Separate relationships and their implication for behavioral intention to use eHealth are explained below.

Perceived usefulness directly affects attitude (β = 0.298, P = 0.00) and intention (β = 0.387, P = 0.00) to use eHealth (H1 and H2), these shows that an increase in health professionals' perceived usefulness leads to an increase in attitude and intention to use eHealth. The probable reason for this could be hence perceived usefulness incorporates effectiveness, ease of use,

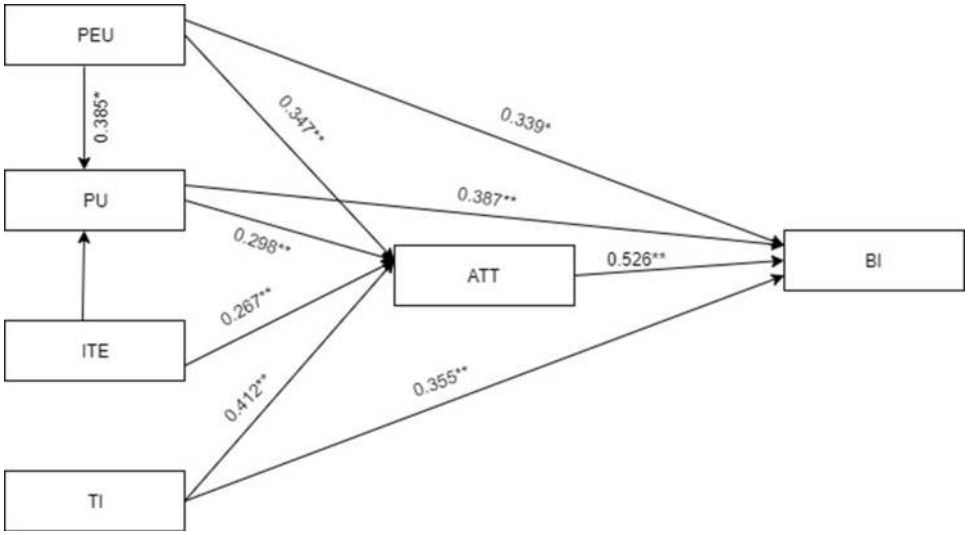

Figure 2 Results of the structural model after a considerable modification of the original TAM model. **Notes:** *p < 0.05, **P < 0.01.

productivity and time efficiency on the systems, the care provider's intention and attitude towards eHealth will be increased. Therefore, a net positive effect from perceived usefulness will result in a positive effect in attitude towards eHealth and intention to use eHealth. This result is consistent with other studies.[14,43,44,49]

Perceived ease of use also endorses a positive impact on perceived usefulness (β = 0.385, P = 0.02), attitude (β = 0.347, P = 0.00), and intention to use eHealth (β = 0.339, P = 0.02) (H3, H4, and H5). When a person believes using eHealth system would be free of effort: their attitude and intention to use eHealth will be enhanced.[48,76,89] Perceived ease of use had both a direct and indirect effect on the intention to use eHealth next to the perceived usefulness construct. This finding is consistent with other studies conducted in different countries.[43,90] This might be due to individual's attitude, perceived usefulness and intention to use eHealth systems is highly influenced by the effort used to manipulate the system. If the system is expected with a less effort to manipulate people's intention to use eHealth systems will be enhanced. Therefore, while implementing eHealth technologies, the system should be easy to understand and operate by healthcare providers for the sustainable adoption of the systems in the future.

Staff's attitude towards eHealth technologies positively affects their intention to use eHealth systems (β = 0.526, P = 0.00), (H9). As healthcare professionals thought eHealth technologies, as a tool to enhance their work performance and the quality of the work they do, their intention to use eHealth also increase. The result is found consistent with other studies.[20,91] The possible reason for this could be the healthcare providers with positive settled way of thinking or feeling about eHealth systems will be highly angered to new eHealth systems. Therefore, activities that boost attitude like computer availability at the workplace, continuous training and support, and knowledge sharing on eHealth technologies should be given a big emphasis.

This study also shows that healthcare professionals' IT experience strongly influences Perceived usefulness (β = 0.595, P = 0.00), and their attitude towards eHealth (β = 0.267, P = 0.02), technologies (H7 and H8). As the staffs have IT experience, having IT knowledge, and getting expertise in hospitals to train them on IT systems their perception of the usefulness of new systems and their attitude towards eHealth will be increased. The result is also found consistent with other studies.[67–70,92] However, the result shows an insignificant association between IT experience and intention to use eHealth (β = 0.062, P = 0.23) (H9). The possible reason for this could be staff with previous IT experience may know the challenges to use eHealth technologies in low-resource settings with interrupted power supply, limited computer access, and a high burden of care providers due to high patient flow. Therefore, before and after the implementation of eHealth systems capacity building of staff in IT is crucial for the sustainable adoption of eHealth technologies in the future. Additionally, it is necessary to provide more computers within the wards to practice and teach themselves without having to wait free computers.

The finding of this study also indicates that the organization's technical infrastructure strongly influences the staff's

attitude (β = 0.412, P = 0.00) and intention to use eHealth technologies (β = 0.355, P = 0.00) (H10 and H11). The result of this study is also found consistent with other similar studies.[14,44,73,93] The probable reason for this could be as the existing infrastructure, the system in place to maintain the hospitals' existing infrastructure increases the staff's attitude, and intention to use eHealth technologies will increase in the same direction. Therefore, ensuring sustainable power supply, availability of computers, allocating budgets are important for attitude and intention to use eHealth technologies in resource-limited setting hospitals.

Conclusion

This study revealed that the advanced technology acceptance model (TAM) to be applicable to assess the behavioral intention to use eHealth for the sustainable adoption of eHealth technologies. Attitude towards eHealth was found to be the strongest determinant factor for the intention to use eHealth. Perceived usefulness and Perceived ease of use were also found an important determinant factor for attitude towards eHealth and intention to use eHealth. Additionally, Technical Infrastructure was also found to be a predicting factor in attitude and intention to use eHealth in Resource-limited settings. Consequently, eHealth implementers and managers in those settings should give priority in improving the hospital's technical infrastructure by providing continuous basic ICT training to health professionals; and give attention to the system they want to implement; hence, those actions will enhance the perceived usefulness and attitude of the staffs indirectly.

Strength and Limitation of the Study

This study will have a significant contribution for the future adoption of eHealth systems in low resource settings. Moreover, the discussed findings were obtained from multi-center study from different eHealth systems in the country that could be generalized to other populations and newly emerged platforms. As a cross-sectional survey, there would be a social desirability bias that is inevitable in a cross-sectional study.

Abbreviations

ATT, attitude; BI, behavioral intention; DHIS, District Health Information System; DSS, decision support system; EMR, electronic medical record; HIS, hospital information system; HMIS, Health Management Information System; ICT, information and communications technologies; ITE, information technology experience; IVR, interactive voice record; PEU, perceived ease of use; PU, perceived usefulness; SEM, structural equation modelling; TAM, technology acceptance model; TI, technical infrastructure.

Data Sharing Statement

Data will be available upon request from the correspondence author.

Acknowledgment

We would like to acknowledge the data collectors and the study participants.

Author Contributions

All authors contributed to study design, data analysis, drafting and revising the article, gave final approval of the version to be published, and have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest for this work.

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