

A review on the issues in usability evaluation of eHealth applications

From a COVID-19 pandemic perspective

Bashair AlThani
College of Business Administration
Imam Abdulrahman Bin Faisal University
Dammam, Saudi Arabia
bfalthani@iau.edu.sa

Abstract— The use of eHealth applications has increased significantly across the globe due to the situations arising out of the recent COVID-19 pandemic. Many new eHealth applications such as mHealth applications for online consultations, health tracking and monitoring, diagnosis etc. were developed, which might have been evaluated using the existing techniques. However, the pandemic has created a situation, which can significantly influence the various processes adopted in the evaluation methods, which may prove to be ineffective due to the unexpected situations arising out of the COVID-19 pandemic. Therefore, the aim of this study is to review the various issues in usability evaluation of eHealth applications in the context of COVID-19 pandemic. The review has identified the need for emphasis on human factors such as attitudes, behaviors, lifestyles, knowledge, and skills; and other environmental factors such as competition, standards, regulations etc. was identified to be necessary in addition to the focus on technical aspects of the system in usability evaluation of eHealth systems.

Keywords—eHealth, usability, evaluation, issues, applications

I. INTRODUCTION

Although, there is no clear consensus on what exactly comprises in eHealth, it is widely acknowledged that all healthcare operations which uses the Internet and communication technologies (ICTs) are considered as eHealth [1]. The recent COVID-19 pandemic has significantly influenced the adoption of eHealth technologies across the globe due to an increased burden on the healthcare systems. The total number of COVID-19 cases globally reached 237.3 million including 4.8 million deaths as reported on 12th October 2021 [2]. Since its emergence, the world has seen three COVID-19 waves at their peak in December 2020, April 2021, and August 2021, which have also seen significant rise in number of deaths [2]. The rise in the COVID-19 cases has forced the countries to implement various suppression and prevention strategies such as lockdowns, curfews etc., which affected the patients suffering from chronic illnesses and those with regular diseases, and the hospitals were already overcrowded with COVID patients. To address the issues in the delivery of healthcare services, various governments have relied on the increased adoption of eHealth technologies. As a result, various studies focused on the relevant aspects such as adoption of eHealth or digital health technologies [3], awareness or knowledge of computer skills, mobile applications [4], awareness of COVID-19 through eHealth applications [5] etc. Accordingly, the global funding for eHealth technology reached \$13.9 billion in 2020; and it is expected to reach

\$38 billion in 2025 [6], indicating a significant growth in the investments in eHealth. According to Mckinsey report [7], the use of telehealth services globally, has increased by almost 80 times in volume in April 2020, which later remained stable at 38 times in volume before the pandemic.

Furthermore, the report estimated \$250 billion spent on remote healthcare services in the US alone during the pandemic, as the consumer attitudes towards eHealth technologies have improved since the emergence of the pandemic, while the barriers such as security and privacy still remained. This indicates that the consumers may be using the eHealth technologies out of need, but not out of interest, as the months in the second half of the pandemic reflected a stable 38 times in volumes, which were dropped from 78 times in volumes in the beginning of the pandemic. Furthermore, there is an increase in the use of virtual agents or automated computer program or bots for providing remote healthcare services, and a significant growth in innovation of remote healthcare technologies was identified with the regulatory changes to promote remote healthcare access [7]. These recent changes: the sudden increase in the adoption of eHealth technologies and a surge in the innovation and development of effective and efficient eHealth technologies has increased the complexity of the usability evaluation of eHealth applications, as the new dimensions and perceptions were emerged in the process of evaluation. The evaluation process of eHealth systems is no more considered as a piece of software or hardware, or a set of interconnected devices, but also consider the actors or stakeholders, physical spaces, and policies. It has become essential to consider the attitudes, behaviors, and the perceptions of the consumers in evaluating the usability of various eHealth applications. For instance, evaluating the COVID-19 monitoring eHealth system may need to consider various perspectives such as the perspectives and conditions of people with issues such as mental disorders, anxiety etc.

As a result, there is a possibility of emergence of new issues in the usability evaluation of eHealth. In this context, this paper reviews the issues in usability evaluation of eHealth applications in different categories presented in the following sections.

A. Technical reliability and appropriateness

While reliability is not a direct non-functional user requirement, but customer requirements should be expressed in terms of benefits reliability can deliver. Compared to other systems, the risk of failure or an error in eHealth system can cause severe damage, sometimes may result in death of a patient. With the increase in the technology interventions, the scope of eHealth has

increased to a wide extent. The eHealth has emerged from the use of single services such as monitoring and tracking of glucose levels through Bluetooth enabled glucose device and smartphone to 24x7 monitoring of glucose, and various other health indicators such as heart rate, blood pressure, oxygen levels, and also behavioral aspects such as sleep time, stress etc., using interconnected devices such as sensors, wearables, and many other interconnected devices, typically referred as the Internet of things (IOT) [8]. Evaluating the reliability and appropriateness of IOT eHealth applications can be challenging, as there are various aspects that need to be evaluated such as accuracy of information (health vitals) being recorded, appropriate communication between the devices etc. For instance, if there is an issue in transferring the glucose data/oxygen levels of an elderly COVID-19 patient by continuous glucose monitor to a connected IOT device, it may cause serious damage to her organs and may sometimes even lead to death. Therefore, not only the device, but also the networks, the communicative environments, protocols etc. must be evaluated. However, in the context of COVID-19, as it is still being studied, there are only few vital measures that are being considered in monitoring patients, such as heartbeat, pulse, oxygen levels etc. However, with the emergence of research, various other measures or indicators may be introduced, and integrating and evaluating these in the new eHealth models may be challenging. Therefore, with the speedy research related to COVID-19, many new measures, indicators, policies, standards, and regulations are being introduced; which makes it a challenging task to evaluate the usability of eHealth applications in the agile environments.

B. Privacy & Security

Privacy is still one of the major issues affecting the technology industry. Though there were significant advances in developing the solutions to protect privacy, breaches are still being observed every now and then in different businesses. The main concern of eHealth systems is the protection of patients' data. Electronic Medical Records (EMRs) or Electronic Health Records (EHRs) have various benefits to both patients and healthcare providers, as they provide complete health related information about patients, including the critical information such as diagnosis reports, medication, personal details etc. However, ensuring the patients' privacy by protecting EHRs is one of the most challenging tasks in managing eHealth systems [9]. As a part of automation of healthcare services, various countries are moving towards adoption of integrated eHealth systems and developing EHRs; but at the same time, the number of security incidents have been increasing. For instance, Anthem, a health insurance provider lost 80 million records of its customer due to a hacker attack, which forced the company to pay \$39.5 million as a part of settlement with the States in the US [10]. Similarly, Science Applications International Corporation (SAIC), was also affected by the data breach resulting in the loss of 4.9 million military clinic and patients records in the US [11].

During the COVID-19, there is a sudden surge in the eHealth users, which can make the existing eHealth systems face various issues in managing the data; which

can become one of the advantageous situations for cyber attackers [12]. According to Deloitte report, the cyber-attacks during COVID-19 have increased by 35% compared to non-pandemic situation [13] in Switzerland. Therefore, it is evident that COVID-19 has affected the usability evaluation of eHealth applications due to sudden change in the number of users and emergency updates in system environment and architecture in various eHealth systems.

C. Interoperability

Interoperability is one of the major challenges in eHealth due to the large volumes of data such as EHRs, EMRs, patient health records, and other types of data such as diagnostic data, monitoring data through wireless/wired sensors, and varying levels of standards and regulations etc. The complexity in the information to be managed is one of the major challenges faced by the eHealth technology developers and the companies adopting eHealth technologies. Furthermore, different types of information which needs to be recorded and managed through the lifetime of the patients, during which there may be several challenges incurred due to the upgradation of legacy systems, implementation/integration of new technology solutions to ramp up the process efficiency and cost reduction and achieve competitive advantage [14-16]. For example, adopting cloud-based technology into eHealth infrastructure may involve serious challenges in integrating data, maintaining the quality of data, and ensuring the successful integration. With rapid changes in the eHealth technologies, such as integration of IOT, which synchronizes the different types of data between various interconnected devices may further create complexity in managing interoperability issues due to the integration of existing systems, i.e., non-interoperable IOT systems into interoperable IOT systems [17-18].

During the COVID-19, sudden surge in the number of eHealth users could have increased the need for additional eHealth architecture, and integration of various systems and data types, which can have serious impact on the functionality, reliability, and accessibility [19,20]. Lack of effective global standards in eHealth management is considered to be one of the major reasons for the issues associated with interoperability in eHealth technologies [21]. Therefore, the future research may focus on developing the global eHealth standards.

D. Gig economy/ outsourcing

Gig economy is associated with the process of outsourcing gigs (small works) to independent gig workers rather than employing permanent employees by the organizations, which can significantly reduce operational costs. Gig economy has a promising future in eHealth as it can benefit the process of healthcare management more efficiently and effectively [22]. Furthermore, gig economy can also benefit in reducing the operational costs by outsourcing gig works [23]. For instance, in eHealth technologies; health service providing mobile applications can provide gigs such as online consultations to professional physicians; and also, other gigs such as online medicine ordering and deliver; or diagnostic gigs such as collection of blood samples for tests at home. Outsourcing such operations to gig workers reduces the costs, as the payment is based on the gig works but not on monthly

basis. However, there may be some serious issues in this process such as privacy and security, as healthcare data is being accessed by the third-party physician/nurse. Furthermore, integrating the patients' health records managed by third-party mobile application/consultant may involve challenges such as data integrity, interoperability issues etc. There was a significant rise in the downloads of mobile health applications which is identified to be 65% growth during COVID-19 pandemic early days compared to prior COVID-19 pandemic period [24]. Furthermore, there is an increasing interest among the physicians to join the gig workforce as it offers flexibility in work, as required [25]. With the healthcare industry, experiencing new business models such as gig economy, the usability evaluation of the eHealth technologies is becoming more challenging due to the changes in business models and users' attitudes, behaviors, requirements, and most importantly expectations.

E. Awareness, acceptance, and readiness

Awareness, adoption, and readiness of the eHealth consumers are the important factors that need to be considered in the usability evaluation of eHealth application. Awareness of eHealth applications such as mHealth (how to use/register, booking appointments etc.), acceptance (acceptance of approaches such as online consultations, which may not go well with certain cultures), and readiness of the consumers for using eHealth applications (possessing enough knowledge and skills) are the three important factors that need to be considered in eHealth evaluation in order to achieve success in its implementation. Studies [26-29] have shown varying levels of eHealth adoption, which is considerably high in high-income countries compared to low-income countries; lack of effective standards or policies in few countries; varying levels of skills and awareness about eHealth among the public; and most importantly lack of regular evaluation of eHealth applications. These differences may increase the complexity of usability evaluation. For instance, in regions where people have less computer/mobile usage skills, the usability evaluation has to be done according to their knowledge levels but not according to the testers' knowledge in organizations. Furthermore, the evaluation process has to be changed according to the changes in the awareness and knowledge of the public with time, which requires regular usability evaluation of eHealth applications. During the COVID-19 pandemic, the rise in the number of eHealth subscribers reflect a sudden change in attitudes of the people, which doesn't mean that they suddenly became aware of eHealth and possess sufficient skills for its adoption. It is possible that their apps are operated by others such as friends/relatives for accessing services such as booking vaccines, booking appointments etc., which can be commonly observed in developing and under-developing countries. Therefore, ever-changing behaviors, lifestyles, knowledge, and awareness of the eHealth users can increase the complexity and challenges in usability evaluation of eHealth applications.

F. Information management

Information overload is one of the major issues affecting the implementation of ICTs in all sectors including, health, education, business etc. Unlike other

sectors, healthcare is one of the most important sectors in which large volumes of information is produced every day, which has to be managed effectively for many years. Many issues may emerge in this process, which may include filter failures such as inadequate information retrieval systems for point-of-care settings, the problem of identifying all relevant evidence in an exceedingly diverse landscape of information resources, and the very basic lack of health information literacy [30]. The process of finding solutions to address the problem of information management largely concentrated on technological means while undermining the humans/patients in the process of managing information [31]. In addition, information overload can also affect the healthcare services such as emergency consultations, in which physicians may need to assess large volumes of patients' information in short times, which not only affects the patients' treatment but also affects physician's health by increasing anxiety and stress [32,33]. Similar cases with information overload leading to anxiety and stress due to information overload was observed among the elderly users of mHealth applications in a study conducted in China [34].

Information overload, such as spread of myths or false information during the pandemic has created a lot of havoc such as burning of 5G towers in the UK, drinking alcohol in Iran for curing COVID-19 etc. Addressing these myths by creating awareness through eHealth applications is a challenging process that increases the real-time monitoring on various issues, and accordingly updating the notifications and messages to the users [35]. Furthermore, evaluating the eHealth applications from the perspectives of people affected by these myths can be challenging, as they may either influence other people over the eHealth network through posts. Therefore, the need for continuous evaluation of eHealth applications may be necessary in order to prevent any damage from the people influenced by false information.

G. Malpractices

Malpractices in eHealth have been increasing in the past few years. Especially the EHR-related claims were on the rise, which were mostly associated with user/physician related aspects such as sloppy copy-and-paste habits, alert fatigue, and workarounds; and also related system functionalities such as data routing problems, inappropriate drop-down menus and failed clinical decision support software [36]. These malpractices reflect a serious patients safety risks associated with the use of EHRs, one of the main components of eHealth system. However, few studies [37] have found that there is a significant decrease in the malpractices after the implementation of EHRs. Similarly, in a study [38] conducted on 1884 physicians in Massachusetts, it was identified that there were 6.1% of physicians with an EHR had a history of a paid malpractice claim compared with 10.8% of physicians without EHRs; indicating the considerable existence of malpractices even after implementing the EHRs. These issues raise the concerns such as liability as the patients' privacy and security are at stake, and the studies [39,40] have highlighted the need for effective training and implementing standards of practice; and the need for physicians to adapt to efficient and effective use of the

electronic information highway to address the issues of malpractices.

Cases of malpractices in eHealth were seen to be increasing during the COVID-19 pandemic, which may be attributed to various reasons such as lack of training and support for physicians, lack of complete knowledge about the treatment procedures for COVID-19, ambiguity in the standards and protocols etc. [41,42]. Therefore, in the event of sudden change such as COVID-19, though it is common to identify the malpractices, it is highly important that the systems are to be effectively evaluated along with the human (physicians/frontline workers) behaviors and attitudes in order to determine the reliability and usability of the eHealth systems. Furthermore, these issues such as malpractices or system errors may lead to poor or ineffective decision-making which may result in severe risks associated with patients' safety. Therefore, evaluating the eHealth system for such issues as malpractices associated with humans may be challenging, as the tester may need to adopt psychology of human behaviors while evaluating the systems.

II. CONCLUSION

COVID-19 pandemic has significantly influenced every aspect of life and business, which have led to the rise of significant challenges in every field of business and service. Healthcare/eHealth is also an important sector that has been influenced by the pandemic. Significant changes have been observed in eHealth in the areas of resource utilization and management; information systems development, implementation, and maintenance; operations and procedures; standards of practice etc. However, the changes in all these aspects have significantly influenced the process of usability evaluation of eHealth applications, which required the reengineering of various procedures and methods of evaluation, and most importantly considering the human related factors such as attitudes, behaviors, knowledge and skills etc.

It is evident from the review that COVID-19 has significantly affected usability evaluation of eHealth applications; and the identification of various areas in which such issues are experienced is an important contribution of this study, which has both theoretical and practical implications. The findings of this review support the need for extending the theory of usability evaluation of eHealth systems in emergency or unexpected situations such as COVID-19 pandemic; and also has practical implication, as the findings can be used as a source of information by software or system testers or evaluators for evaluating the usability of eHealth applications. This study also has few limitations, as it only considered seven important areas, where the issues in usability evaluation of eHealth systems was considered; but there can be more areas to be investigated such as trust, decision-making, liability, legal regulations etc., which may be addressed in future studies.

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