The Role of Technology Acceptance in Healthcare to Mitigate COVID-19 Outbreak

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Abstract The recent decade has included huge achievements in the development for information technologies in healthcare. Now, these technologies can be employed as part of the response to the COVID-19 pandemic. Information technologies in healthcare are crucial to store, manage and exchange the clinical data. On the other hand, the success or failure of a specific technology relies on the acceptance to use that technology. There is a need to assess the user’s technology acceptance prior to the development or improvements for that technology. The study objective is to systematically review the studies that empirically had evaluated the acceptance of technology in healthcare through the technology acceptance model (TAM), its extensions and integrated models based on it. Also, the study will highlight the various studied technologies in healthcare arena, and how these technologies can be utilized to provide the health services, as a respond to the on-going pandemic. PRISMA guidelines were used to perform the review; and the search process has been completed using six digital libraries: Google Scholar, PubMed, IEEE Xplore, Springer Link, ACM, and Science Direct. Out of 1768 studies, a total of 99 empirical studies were found to be eligible and included in this study. A thorough statistical analysis was achieved, to understand the situation of technology acceptance as in the recent decade. The analysis included the key factors, as they were extensively utilized to clarify the technology acceptance, along with the key confirmed hypotheses to build robust and valid technology acceptance models in healthcare. It was found that electronic records, tele-medicine and mobile health solutions have attracted the most of researchers in the last ten years. Where the acceptance of those solutions was explored, through various user types and settings, within different countries particularly Taiwan and the United States; who are leading this research domain.
Keywords  COVID-19 · Technology acceptance model · Healthcare · Systematic review · PRISMA

1 Introduction

Apart from the health perspective, the impact of coronavirus has expanded to every single side of our lives. Basically, the key objective for the development of technology solutions healthcare was to ease the delivery of health services, instead of necessity [1]. As per the healthcare professionals, the key precaution to reduce the spread rate is to maintain the social distancing rules [2]. So, the initial reaction from the governments was to minimize or even stop all clinical services [3]; which opened the door to make the use of information technologies essential. Globally, healthcare organizations are trying to use different technologies to provide their medical services while patients are stayed at homes, i.e. tele-medicine technologies, especially that many cases can be managed and treated effectively from a distance [4–6]. Also, other solutions can help to reduce the number of visits during this pandemic or even in the future including mobile health services [7], [8], and health portals [9–11].

To ensure the success of any information technology, it is important to have the user’s acceptance for that technology [12]. Low level of acceptance for a specific information technology may result to failure, or at least slowness in the execution of that technology [13–15]. In healthcare, the absence of technology acceptance has negative influence on the key objectives, i.e. patients’ data management and storage [16]. Technology acceptance indicates the positive psychological status towards the usage intention of innovative technology solutions [17–19]. Technology acceptance is constant process due to the continuous changes in the requirements of users, and significant at any time of the technology life cycle; including the design and after implementation phases [20]. It is obvious that information technologies are continuously getting extended in healthcare domain [21]. Information technologies facilitate the quality of clinical services, and maximize patient’s safety. As well, information technologies is playing vital role to enhance healthcare staff’s work efficiency and effectiveness [22].

Through the years, the Technology Acceptance Model (TAM) [23–29], its extensions [30, 31] and modifications have been employed, to explain acceptance of various information technologies in healthcare domain [32–35]. Where these technologies Include healthcare websites [10], mobile applications [16], tele-medicine solutions [36], electronic health records [37]. The objective of this study is to provide an overview for the studied technologies in healthcare, with respect to the technology acceptance. Through conducting a systematic review, the study aims to explain the situation of technology acceptance literature in healthcare. The study is looking to clarify the current direction of technology acceptance literature, and how it can be improved to facilitate in the battle with COVID-19 virus or other similar crises in future.
Moreover, it is not possible to deny the other conducted reviews, to survey the technology acceptance in healthcare arena [22], [38–45]. On the other hand, this review is novel for several reasons. First, the study will include only studies with empirical assessment for TAM, its extensions, and modifications. Second, the review will discuss those technologies with respect to their role to respond to the current pandemic (COVID-19). Third, different information technologies will be reviewed in the study, and not only one technology, e.g. Electronic Health Records. Fourth, studies with various settings and user types were considered. Fifth, the reviewed studies were published in the last ten years (2010–2019), to provide new summary about the literature. Finally, this study will discuss different implications, and future directions that are vary from other reviews.

2 Novel Coronavirus (COVID-19)

With its high levels of spread and unique composition, COVID-19 is considered the most known pandemic disease [2, 46]. Nevertheless, other respiratory viruses from the same family of Coronaviruses have arisen with severe harms. Porcine Epidemic Diarrhea—PED virus, Severe Acute Respiratory Syndrome—SARS, and the Middle East Respiratory Syndrome-MERS [47]. In 31st of December 2019, the China office of World Health Organization (WHO) has reported cluster of cases with new pneumonia in the city of Wuhan, China. Since then the virus became aggressive and spread quickly to the whole world [48].

The impact of COVID-19 is now linked to every aspect of people’s lives such like education, healthcare, jobs and world economy. While we are in August 2020 and the pandemic is still going on, most of the schools and universities are still closed which is causing an interruption in the learning process; with lower prospects of students’ growth and development. As well, The delivery of online learning had become big challenge for several educational institutes during this pandemic [49]. In addition, many healthcare services have been reduced or even stopped [3]; including the delivery of surgical services and care for many patients [50]. Moreover, the outbreak and evolution of COVID-19 have created high levels of uncertainty and deactivated the global economy. So, it is hard for decision-makers to formulate a suitable response for the macroeconomic policy [51].

By the mid of August 2020, A total of 21,368,534 cases of Coronavirus have been reported from 213 different countries and territories. Out of the total reported cases, still 6,445,473 cases are active and 14,923,061 were closed due to recovery (95%), or deaths (5%) [52]. These numbers are scaring, and needs a huge global collaboration especially in the scientific research, vaccine industry and the development information technology.
3 Research Methodology

Various digital databases have been explored, by conducting a review for the published studies. The goal was to obtain findings from the studies that empirically have studied the acceptance of technology in healthcare arena. The review of prior related literature is considered key phase through the execution scientific study. In general, reviews are helpful to ease and expand the development of theory, important to fill research gaps when it is mandatory, or lock the research area where a plethora of literature is available [53]. Systematic review is providing the support researchers, to become familiar with their research topic [11] and previous concepts [54–58]. Unlike the traditional or narrative review, Systematic reviews are more rigorous, and suggest well-defined methods to analyze the literature of specific topic [11].

The review within this study was performed based on the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA), as in Fig. 1 [59, 60]. Consequently, the utilized approach to recognize studies and collect the required data has contained various stages: specify the inclusion and exclusion criteria, identify the digital databases to explore, define the strategies to search each digital library, and perform the relevant analysis for the retrieved research papers.

![PRISMA flow diagram](image)

Fig. 1 PRISMA flow diagram
3.1 Search Strategy

Six digital databases were employed to search for the required studies: Google Scholar, Springer, IEEE Xplore, PubMed, Science Direct and ACM digital library. These databases have been explored to retrieve studies, as being published from January 2010 to December 2019 (10 years). The development of search strategy accomplished by defining particular search keywords as in Table 1, and search criteria based on the search features of each digital library. The search keywords and strategy were followed, and the initial results contain 1768 studies as a total as seen in Table 1.

3.2 Selection Criteria

The selection criteria were specified, and included the inclusion and exclusion rules as in Table 2. It is vital to define selection criteria, so the study can easily be classified as valid and guarantee reliability in the collected studies and data analysis. So, the inclusion criteria presented the following rules:

3.3 Data Abstraction and Analysis

The citations of all studies were downloaded to Mendeley reference manager [61]. The rules of inclusion criteria have been applied, a quick screening for titles and abstracts took place to filter the studies. In case of passing those two rounds, the full paper will be retrieved and saved in another folder for final review round. Prior to the data analysis, the eligible studies will be copied to new folder.

Data extraction took place through four phases. The first two stages were to classify the studies as per the type of used model to evaluate the technology acceptance, and to classify the papers as per the studied technology in healthcare.

| Table 1 | Summary of search keywords |
|---------|---------------------------|
| ID      | Keywords                  |
| 1       | (“Technology Acceptance”) AND (Healthcare OR Health OR Medical OR Physician OR Nurse OR Patient) |
| 2       | (“Technology Adoption”) AND (Healthcare OR Health OR Medical OR Physician OR Nurse OR Patient) |
| 3       | (“Technology Acceptance”) AND (Healthcare OR Health OR Medical OR Physician OR Nurse OR Patient) AND (“Intention to use” OR “Actual use”) |
| 4       | (“Technology Adoption”) AND (Healthcare OR Health OR Medical OR Physician OR Nurse OR Patient) AND (“Intention to use” OR “Actual use”) |
Third stage to sort the studies as per the year of publication, type, and country where the study has been conducted. The aim of the fourth phase was to explore the extensively used external factors, recognize the confirmed hypotheses among these factors, by analyzing the findings of each study.

4 Results and Discussion

As seen in Fig. 1 and Table 3, the initial search results included 1768 studies as retrieved from the digital databases. After removing the duplicates (916 records), 852 studies were valid to enter the screening stage. Titles and abstracts have been
reviewed for the 852 studies. It was found that 638 studies need to be excluded, due to their unsuitability with the inclusion criteria. At the end, full texts were quickly scanned for 214 publications, in order to confirm the achievement of other inclusion rules. A total of 99 studies were recognized as valid and eligible to be included in the analysis process at this study. Table 4 provide summary for all the eligible publications with integrated models based on TAM.

5 Study Implications

The empirical studies of technology acceptance in healthcare were systematically reviewed, and analyzed, to provide a comprehensive summary the literature in last decade. This summary can be used to shape the direction of research and improve it, where the direction should help to serve the mitigation of the negative impact of COVID-19 on the healthcare service. The mitigation can include the development of new information technologies or enhancements for the current implemented technologies. To achieve these objectives, the acceptance of various technologies in healthcare was reviewed through analyzing the publications between January 2010 and December 2019. The selected theory to review was TAM as proposed by [23], its extensions and modifications since TAM is the prevailing model to understand the user’s technology acceptance in healthcare [53].

Perceived ease of use and perceived usefulness are the key constructs of technology acceptance model, and have been extensively used in several studies to measure the level of acceptance for various technologies in healthcare [85–88]. It was confirmed that these two constructs are capable to clarify around 40 percent of user’s intention to use and adopt information technologies [41], in different domain plus healthcare [40, 89, 90]. As seen in Fig. 2, the original TAM and its extensions were utilized in 76 studies as per the performed review. While other integrated models based on TAM were proposed in 23 studies, to evaluate the acceptance of technology in healthcare. Such results confirm the suitability and powerful state of TAM, and its constructs to explain the acceptance of different technologies through different types of users. But the result is delivering an implicit message regarding the importance to integrate TAM with other models, and inject other factors to extend the explanatory power of TAM, as proposed by [91].
| Source | Year  | Type       | Technology                                           | Sample Size | Sample type                          | Country     | Model                                                                 |
|--------|-------|------------|------------------------------------------------------|-------------|--------------------------------------|-------------|-----------------------------------------------------------------------|
| [62]   | 2010  | Conference | Computer assistance Orthopedic surgery system       | 115         | Healthcare Professionals             | Taiwan      | Integrated model: TAM & TPB                                          |
| [63]   | 2010  | Journal    | Tele-homecare Technology (Telemedicine)             | 40          | Physicians                           | USA         | Compare two models: TAM & TPB                                        |
| [64]   | 2011  | Journal    | Healthcare information systems                      | 366         | Nurses, Head directors and other related personnel | Taiwan      | Integrated model: TAM & IS success model                              |
| [65]   | 2012  | Journal    | Health information technology (HIT)                 | 728         | Users of online health Information   | South Korea | Integrated model-health information technology acceptance model (HITAM): HBM, TPB & TAM |
| [66]   | 2012  | Conference | Clinic information system                           | 252         | Doctors & staff                      | Malaysia    | Integrated model: TAM & TPB                                          |
| [67]   | 2013  | Journal    | E-learning system                                   | 218         | Nurses                               | Taiwan      | Integrated model: TAM & flow theory                                  |
| [68]   | 2013  | Conference | Health information system (HIS)                     | 252         | Staff in private healthcare organizations | Malaysia    | Integrated model: TAM & TPB                                          |
| [69]   | 2013  | Journal    | Personal digital assistant (PDA)                    | 222         | Physicians                           | USA         | TAM, TPB, and IDT                                                     |
| [70]   | 2013  | Journal    | Clinic information system (CIS)                     | 252         | Doctors & staff                      | Malaysia    | Extended hybrid model: TAM & TPB                                     |
| [71]   | 2014  | Conference | Health cloud services                               | 443         | Patients                             | Taiwan      | Integrated model: TAM & SQB                                          |

(continued)
Table 4 (continued)

| Source | Year | Type          | Technology                                           | Sample size | Sample type     | Country        | Model                                                   |
|--------|------|---------------|------------------------------------------------------|-------------|-----------------|----------------|---------------------------------------------------------|
| [72]   | 2014 | Journal article | Electronic health record (EHR)                       | 150         | Physicians      | Canada         | 4 models: TAM, extended TAM, psychosocial model & integrated model |
| [73]   | 2014 | Journal article | Innovative smartphone                                | 122         | Hospital professionals | S. Korea     | Integrated model: TRA, TAM & IS success model             |
| [74]   | 2014 | Journal article | Telehealth system                                    | 365         | Patients        | Taiwan         | Integrated model: extended TAM & HBM                      |
| [75]   | 2015 | Conference     | Consumer Health informatics applications             | 105         | Health Consumers | Malaysia       | Integrated model: TAM, TRA & UTAUT2                       |
| [76]   | 2015 | Journal article | Health-related internet use                          | 293         | Female users    | Malaysia       | Integrated model: HBM & TAM                              |
| [77]   | 2015 | Journal article | Mobile electronic medical Records                    | 158         | Physicians      | Taiwan         | Integrated model: TAM and Dual Factor Model               |
| [78]   | 2016 | Journal article | Health information technology: pharmaceutical service systems | 1420   | Pharmacists/ pharmaceutical assistants | Turkey         | Integrated model (P-TAM): TAM, UTAUT & TPB               |
| [79]   | 2016 | Conference     | Hospital information systems                        | 100         | Hospital staff & doctors | Indonesia     | Integrated model: TAM & DeLone and McLean IS success    |
| [80]   | 2016 | Journal article | Computerized clinical practice guidelines            | 238         | Physicians      | Taiwan         | Integrative model of activity theory and TAM              |
| [81]   | 2017 | Conference     | E-health services consumer informatics               | 91          | Citizens        | Indonesia       | Extended model: TAM & HBM                                |

(continued)
| Source | Year | Type           | Technology                  | Sample size | Sample type       | Country | Model                                      |
|--------|------|----------------|-----------------------------|-------------|-------------------|---------|--------------------------------------------|
| [82]   | 2017 | Journal article| Nursing information system  | 531         | Nurses            | Taiwan | Integrated model: TAM & ISSM              |
| [83]   | 2019 | Journal article| Smart wearables             | 146         | 60 + years old adults | China  | Extended hybrid model: TAM & UTAUT        |
| [84]   | 2019 | Journal article| Telehealth                  | 281         | Adults 40+        | Taiwan | Integrated model: TAM & SQB               |
As one of the important objectives in this study, the studied technologies were reviewed. The goal is to recognize what are the prevailing technologies, and to decide whether these technologies are in line with the direction to implement and push for the use and acceptance of E-health services. These services and technologies that can help to mitigate the impact of COVID-19 and reduce its levels of spread, by providing the required treatments or consultations for patients while they stay at home, as a part of the social-distancing precautions. It is essential to study the acceptance of these technologies, to decide how they can be improved, and what is impacting the intention of people to use these applications to support in the battle against the coronavirus.

With a total percentage of 58.6% in term of utilization, it was clear that the research is dominated by three main categories, Telemedicine Solutions, Mobile Health Services, Electronic Records Solutions (e.g. Health information solutions, electronic medical records and electronic health records), as seen in Table 5. Although a plethora exists in the research related to these categories, it is beneficial for the mitigation of COVID-19 impact. Nowadays, telemedicine is experiencing a rapid growth, since it is effective solution to achieve the social-distancing in clinics, and provide the needed health services [1, 4]. Despite the past slow implementations of telemedicine [4], this situation of growth increases the need to study and apply the acceptance of telemedicine, in order to accelerate the adoption, ensure the success of the solution, and facilitate in the mitigation for the impact of COVID-19.

As the virus is quickly spreading and its negative impact is increasing, the active learning curve about it is getting higher. Such daily active learning is helpful to empower the information about its origin, root-cause and the required pre-cautionary measures. Electronic records solutions are playing vital role to collect, store, organize the patient’s data, it can increase the production of data in the healthcare field [92]. So, to enhance the data collection and organization
processes, it is recommended to review the literature that is related to the adoption and acceptance of electronic records solutions in healthcare. On the other hand, it is mandatory to implement data analytics tools to increase the benefits of electronic records solutions, through proper integration. The review found that there is a lack of studies related to the acceptance of analytics tools. Analytics tools are related to the big data theory, and it is helpful to guide policy-makers in individual country. By giving the chance to design suitable models that can explore and study the activity of the virus, big data analytics solutions can improve the process of preparation for the virus outbreak [3]. Besides, the acceptance of other helpful technologies like robotics can be explored. Robotics can play vital role in the application of E-health services to achieve the precaution measures of social-distancing.

Additionally, the results of mobile health services (14.1%) and health websites (7.1%) studies are promising. Mobile applications and internet-based websites can enable the self-guided data collection on the population level, then the results be swiftly circulated to participants to be apprised about the health emergencies [93]. These analyzed studies can form the foundation to decide what is required to develop and enhance mobile applications, or websites for the healthcare purposes and especially in such pandemic cases. For instance, UAE has launched a mobile digital platform “ALHOSN”, as a joint national initiative to protect the community. The application can operate on both: Android [94] and IOS [95], and works by collecting the results of coronavirus tests, from different public and private healthcare entities. These results can help in contact tracing, and determine the geographical hot spots nationwide. The stats of studied technologies as discussed in the analyzed studies can be found in Table 5 and Fig. 3.

Furthermore, we cannot deny where the studies have been conducted which can help to recognize the research gap, in some countries or regions. This study could address the origin of each publication to improve the direction of research, and create additional motivation for researchers. For example, the analysis found that the Central and South America regions have contributed with zero studies to the literature of technology acceptance in healthcare, as highlighted in Fig. 4. These

| ID | Studied technology              | Frequency | (%)  |
|----|--------------------------------|-----------|------|
| 1  | Barcode technology             | 3         | 3.0  |
| 2  | Cloud health services          | 3         | 3.0  |
| 3  | E-Learning and education       | 6         | 6.1  |
| 4  | Electronic records solutions   | 27        | 27.3 |
| 5  | Health portals/websites        | 7         | 7.1  |
| 6  | Mobile health services         | 14        | 14.1 |
| 7  | Tele-medicine technology       | 17        | 17.2 |
| 8  | Wearables devices              | 4         | 4.0  |
| 9  | Others                         | 18        | 18.2 |
| Totals |                                   | 99       | 100  |
results mean that there is a research gap there, and it needs to be covered. It can be
an indication for the rare adoptions and implementations for technology in
healthcare field, at these two regions. To prevent any bias, there is a possibility that
many technology acceptances studies have been published in Spanish, or
Portuguese since these are the commonly used languages there. Additionally, a
limited number of studies were achieved in Arab and African as developing
regions. Although UAE and Jordan have advanced healthcare systems and suc-
cessfully implemented a lot of healthcare applications, only three studies were
conducted in UAE, and two studies in Jordan. So, it is obvious that these countries
are facing a gap in research of technology acceptance in healthcare which may
negatively impact the development or improvements of information technologies in
healthcare, and consequently affect the mitigation of COVID19 outbreak.

**Fig. 3** Number of publications per studied technology

**Fig. 4** Geographic chart for the studies as included in this study
On the other hand, Asia was found to have the highest number of published studies (56) in technology acceptance in healthcare. Remarkably, Taiwan has recorded more than 21% of the total analyzed studies, which equals 37.5% of total studies in Asia. This might refer to the well-established healthcare system in Taiwan [96]. Also, the United States as a first runner-up with results of 14 empirical studies to measure the technology acceptance in healthcare. The results of the United states can be considered poor, considering that the united states is the global leader in terms of science and technology research as per the 2018 report of the National Science Foundation’s (NSF) Science and Engineering Indicators [97]. More geographical details for the analyzed studies are illustrated in Figs. 5 and 6.

Finally, a categorization per year of publication was performed. An increment can be noticed from 2010 till 2012, with more or less constant frequency till 2016. There was a drop in number of published studies from 2017 and ongoing, which

![Fig. 5 Publications statistics per region](image)
![Fig. 6 Publications statistics per country](image)
can extend the research gap. It seems that the interest to explore the acceptance of technologies in healthcare is getting declined as we can see in Fig. 7. These low numbers, or low interest levels are not helpful in terms of COVID19 mitigation, and huge research work should take place. Government authorities, universities and research centers need to collaborate, formulate appropriate polices, and assign required budgets to motivate the research work of technologies in healthcare, especially those that can facilitate the application of E-health services in such pandemic cases.

6 Study Implications

The study purpose was to provide an overview for the current literature of technology acceptance in healthcare. The studied technologies were reviewed, and assessed to know if they are aligned with the current need to apply the E-health services, due to the situation of COVID19 outbreak. This review considered unique in this crisis’s situation, and could provide number of theoretical and practical implications.

First, various technologies were reviewed along with different types of users instead of one type. This added a diversity characteristic to this review, and can be positive to give wider view for researchers, and policy-makers. Second, this review helps to improve the theory of technology acceptance, by recognizing the prevailing technologies in healthcare, the research areas that need to be covered and the location of each research. Third, the review can be helpful to form the direction of technology research, in a way that can serve to mitigate the negative impact of COVID19 on the healthcare services. In contrast, the review can be practical by
building the required foundation for other researchers. It gives the required track to follow, to know which technologies are essential in this time of pandemic, and needed currently to be studied in terms of technology acceptance in healthcare. The review is considered supportive, to identify what is impacting the acceptance of these technologies, and how to enhance the user’s acceptance to help during the current or future crises. As lessons-learned, information technology providers and healthcare organizations can utilize the findings of this review to improve the current developed solutions, consider optimizations to serve in this pandemic, or avoid mistakes that can lower the levels of user’s acceptance for technology.

7 Conclusion and Future Work

The study objective is to review the recent literature technology acceptance in healthcare domain, and build clear perception about the studied technologies and how they can facilitate in the mitigation of COVID19. To achieve these objectives, the study employed a systematic review methodology based on PRISMA guidelines. A total number of 1768 published studies have been reviewed, and 99 studies were identified eligible to be analyzed. The analysis of the review could confirm the availability of promising findings, with a lead for technologies that can be helpful to reduce the impact of COVID19 break, the negative impact on the health services in this case. Those leading technologies include telemedicine solutions, mobile health services, and electronic records solutions (electronic medical records, health information systems…etc.). As well, there is a room to study other technologies like robotics and big data analytics solutions, where these technologies can play vital role in the application of E-health services to comply the precaution measures of social-distancing. In general, it was found that the reviewed studies were mostly performed in Taiwan, and the United States. Arab and African countries as part of developing regions, are still lagging behind in terms of the technology acceptance research. In spite of the advanced healthcare systems, and the successful of adoption for information technology in some Arab countries, i.e. UAE and Jordan, it is obvious that there is a gap of research with relation to technology acceptance in healthcare. This shortage of research can negatively impact the development or improvements of information technologies in healthcare, due to the absence of understanding to the factors that impact user’s acceptance, and accordingly affect the mitigation of COVID19 outbreak.

As a clear limitation, the virus is still new and its effects have not been fully disclosed, which caused difficulties to conduct this research due to the scarcity of published literature related to the risks and consequences of COVID19. Also, the available COVID19 literature is still scattered especially from technology perspectives. In the future there should be an obvious direction of how technology and its acceptance can minimize the negative impact of COVID19. The results of this review can be utilized to produce meta-analysis to facilitate in the research direction. Moreover, only one technology model (TAM) was included in this review. To
extend this view, the acceptance of technology in healthcare can be reviewed as studied through other theories other than TAM. As well, considering the studied factors and constructed hypotheses in these analyzed studies. This can be helpful to know from where we have to start, and what to include to understand the enablers and barriers of technology adoption in healthcare, with respect to COVID19 outbreak and mitigation.

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