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The adoption of mobile health applications by physicians during the COVID-19 pandemic in developing countries: The case of Saudi Arabia

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ABSTRACT

The rapid evolution of mobile health applications (mHealth apps) has become increasingly important in enhancing healthcare delivery, especially during the COVID-19 pandemic. Despite the critical role of such technologies, however, acceptance and adoption rates among physicians in developing countries, particularly Saudi Arabia, have been relatively low. This highlights the need to explore the determinants of acceptance. In response to this call, this study aimed to identify the factors that influence Saudi physicians' acceptance and adoption of mHealth apps during the COVID-19 pandemic using the unified theory of acceptance and use of technology. Data were collected using an online survey, after which the responses were analyzed via structural equation modeling. The analysis assessed the influence of four primary constructs, namely, performance expectancy, effort expectancy, social influence, and facilitating conditions, on the physicians' behavioral intention to adopt these technologies. The results indicated that while all factors significantly affected the intention to adopt the apps, facilitating conditions were the most influential. These findings punctuate the necessity of investing in infrastructure and implementing training programs focused on integrating mHealth technology into medical practice. By drawing attention to influencing factors, this research provides critical insights for policymakers and healthcare managers to enhance the adoption of mHealth apps. This enhancement, in turn, can help improve healthcare delivery and patient outcomes during and beyond health crises. Finally, this study not only sheds light on the adoption dynamics prevalent in a developing context but also serves as a valuable guide for implementing similar technologies in other global regions.

1. Introduction

The healthcare sector is a critical domain that affects the global population and is fundamentally linked to the development of any nation. The importance of healthcare in daily life demands the provision of high-quality services that encompass treatment, care, and operational aspects, which are crucial across various facets of society (Jonkisz et al., 2021). Such services are delivered to individuals by healthcare facilities equipped with the resources necessary for this purpose (Jamil et al., 2020), but this task is an extremely complicated process involving the diagnosis, treatment, and prevention of diseases, injuries, and other physical and mental impairments (Khatoon, 2020; Pereira Detro et al., 2020). Healthcare systems worldwide face several challenges, with developing countries particularly struggling to deliver consistent and adequate services (Ahmed et al., 2020; Chakraborty et al., 2021). For example, accessing healthcare services is difficult, especially for populations in remote areas, where disparities between urban and rural healthcare provision are pronounced (Bristow et al., 2021; Sasaki et al., 2021). These inequalities in access often confront rural populations with serious health issues, including higher rates of disability, cognitive impairment, and mortality (Harrison et al., 2020). In addition to the delivery and accessibility of healthcare services, the increasing prevalence of chronic diseases presents a considerable hurdle to healthcare systems worldwide (Al Asmri et al., 2020; Chudasama et al., 2020; Jarrar et al., 2023; Kendzerska et al., 2021). The incidence of chronic conditions has increased dramatically, making these diseases major contributors to morbidity and mortality (Al-Hanawi, 2021; Okoroiwu et al., 2020).

Beyond the existing problems of healthcare systems, the COVID-19 pandemic has substantially exacerbated pressures on health services

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globally. In March 2020, the World Health Organization officially declared the pandemic to be caused primarily by the COVID-19 virus (Mansour, 2021), which has presented a challenge to humanity given its considerable effects on several sectors, especially healthcare (Alhasan et al., 2022; Alzahrani et al., 2022). The pandemic has affected millions globally, causing multiple waves of infections and leading to a considerable increase in mortality rates (Woods et al., 2020). The sudden global outbreak caught the healthcare sector unawares (Filip et al., 2022), challenging the ability of healthcare professionals to provide standard care and severely affecting their own safety and protection (Abdel-Basset et al., 2021). This situation was made worse by lockdown periods and issues arising from the management of COVID-19 cases (Mitra & Basu, 2020; Roy et al., 2021). Health systems, which are already overburdened, are put under tremendous strain by their obligation to provide healthcare while eliminating face-to-face communication to minimize virus transmission (Echelard et al., 2020; Houlding et al., 2021).

In Saudi Arabia, the context of interest in this study, the government guarantees free healthcare services for all citizens, ensuring that everyone has access to essential medical care without financial burdens (Al-Hanawi et al., 2020). However, the Saudi healthcare system has also faced serious challenges that have impacted its overall efficiency and effectiveness. These challenges include the considerable shortage of qualified healthcare professionals, such as physicians, nurses, and allied health workers (Al Asmri et al., 2020; Al Saffer et al., 2021). This shortage has driven a heavy reliance on expatriate professionals, which creates workforce instability, as these practitioners are unlikely to remain in the country in the long term. High turnover rates among expatriate healthcare professionals diminish productivity, necessitating the continual recruitment and training of new staff (Mohammed & Waleed, 2022). Furthermore, the number of individuals with chronic diseases in Saudi Arabia has remarkably increased in the past decades (Al Asmri et al., 2020; Jarrar et al., 2023). Among these health conditions, diabetes is particularly critical, with its prevalence ranking the country among the top 10 worldwide (Jarrar et al., 2023). These figures are a primary public health concern because diabetes is related to increased mortality, morbidity, and vascular complications accompanied by public health and quality of life issues (Al-Hanawi, 2021; Okoroiwu et al., 2020). Ensuring the provision of healthcare services is a challenge in Saudi Arabia also because it is a vast country spanning more than 2,150,000 square kilometers of territory (Alanazi & Alanazi, 2023). It is beset with inequalities that have left rural regions with fewer and under-resourced facilities compared with urban regions, rendering access to such facilities one of the main barriers to healthcare for rural patients (Al Asmri et al., 2020; Amin et al., 2020).

The abovementioned challenges drove the rapid use of digital innovations, especially during the pandemic, as a means of providing immediate and effective solutions to healthcare-related crises (Crawford & Serhal, 2020). This situation created a valuable opportunity for developers specializing in mobile health applications (mHealth apps) to provide easily accessible platforms that enable the general public to access healthcare services (Ming et al., 2020). These apps have advanced the remote provision of healthcare services, reduced the need for face-to-face consultations, and contributed to the effective surveillance and control of diseases (Alzahrani et al., 2022; Asadzadeh & Kalankesh, 2021).

Despite their potential advantages, however, their acceptance and adoption have been limited, particularly in Saudi Arabia (Aljohani & Chandran, 2021a; Alsswey et al., 2021; Rajak & Shaw, 2021; Wu et al., 2022). This peculiarity has encouraged researchers to investigate potential barriers to using such technologies. The problem is that the literature predominantly focuses on developed nations or the perceptions of patients (Alam et al., 2020a; Aljohani & Chandran, 2021a; Dahlhausen et al., 2021; Deng et al., 2018; Edo et al., 2023; Li et al., 2021). This focus creates a considerable gap because developed and developing countries differ in the factors that affect technology adoption, such as healthcare infrastructure, technological availability, socioeconomic situations, and cultural attitudes (Alsahli et al., 2023; Getachew et al., 2022). Furthermore, patients' perspectives are important, but acceptance by healthcare professionals and the integration of technologies into their practices are critical to the adoption of mHealth applications (Alsahli et al., 2023). Studies have frequently failed to consider specific factors from the perspectives of physicians, who are the primary users of these technologies (Kong et al., 2020; Wu et al., 2022).

In consideration of these issues, the current study aimed to identify the factors influencing physicians' acceptance and adoption of mHealth apps during the COVID-19 pandemic in Saudi Arabia. The findings provide meaningful insights for policymakers, healthcare managers, and mHealth developers by helping them understand the barriers to and facilitators of mHealth usage in healthcare settings. This comprehension is crucial in efforts to encourage the use of mHealth technology, which can improve healthcare delivery, patient outcomes, and medical efficiency during and beyond the pandemic.

2. Literature review

2.1. Impact of COVID-19 on healthcare systems and the role of mHealth apps in the pandemic

The healthcare sector has faced urgent and critical issues in the COVID-19 pandemic. For example, there was an extreme shortage of beds, personal protective equipment, and medical equipment in multiple hospitals due to the tremendous increase in patients needing treatment (Clay-Wililams et al., 2020; Sen-Crowe et al., 2021). This situation drove a high demand not only for unique treatments for COVID-19 patients but also for protective measures for healthcare professionals who were in direct contact with these patients (Monaghesh & Hajizadeh, 2020). In this respect, technological solutions have the potential to enhance and optimize the response of communities and healthcare systems to outbreaks of infectious illnesses (Alam et al., 2021; Asadzadeh & Kalankesh, 2021). Among these technologies, mHealth apps, have elicited tremendous global attention as preventive measures against the COVID-19 pandemic (Alam et al., 2021; Casalino et al., 2023; Kondylakis et al., 2020).

The term "mHealth" is defined as the use of mobile technologies, including smartphones, wearable devices, and tablets, to support the delivery of healthcare services by healthcare professionals to patients (Said, 2022; Yang et al., 2021). It presents a promising opportunity to generate advantages for healthcare professionals and patients during the pandemic (Mansour, 2021). For instance, mHealth technologies can maximize service delivery even under reduced face-to-face health consultations (Asadzadeh & Kalankesh, 2021; Kondylakis et al., 2020), thus enhancing the safety of healthcare professionals and patients (Asadzadeh & Kalankesh, 2021). Furthermore, the geographical information made available through mHealth innovations aids the identification of COVID-19 infections by tracing cases, thereby advancing control over further spreading (Altmann et al., 2020; Alzahrani et al., 2022). These technologies can also improve the management of chronic diseases (Said, 2022; Salas-Groves et al., 2023), provide access to reliable information (Kondylakis et al., 2020; Said, 2022), and reduce the costs of healthcare services (Abbaspur-Behbahani et al., 2022; Alhasan et al., 2022).

With the advent of the global outbreak, multiple mHealth apps were introduced or upgraded according to the needs and demands of the time. Some of these apps were Apple's COVID-19 app, COVID Symptom Tracker, Patient Sphere for COVID-19, and CoronaFACTS (Ming et al., 2020). In Saudi Arabia, the Ministry of Health launched and upgraded several mHealth apps to deal with healthcare-related crises (Alassaf et al., 2021; Hassounah et al., 2020). For example, the Sehhaty "My Health" app enables users to have audiovisual consultations with healthcare professionals, book COVID-19 testing and vaccination, and acquire immediate guidance on treating possible side effects (Alassaf

et al., 2021). Tawakkalna is another app equipped with GPS technology that monitors and regulates individuals' mobility within curfew hours and generates permits for exceptional circumstances (Hassounah et al., 2020).

2.2. Acceptance and adoption of mHealth apps

Despite the availability and considerable potential of mHealth apps, their acceptance and adoption remain relatively low (Kong et al., 2020; Rajak & Shaw, 2021; Said, 2022; Wu et al., 2022), prompting researchers to address potential deterrents to the use of such technologies. The majority of studies have focused on perceptions regarding patients' behavioral intention toward using these technologies (Alam et al., 2020a; Alwashmi et al., 2020; Deng et al., 2018). These explorations identified perceived usefulness, ease of use (Alwashmi et al., 2020; Deng et al., 2018), performance expectancy, and social influence (Alam et al., 2020a) as significant positive predictors of mHealth app adoption. They indicated privacy concerns, performance risks (Deng et al., 2018), technical matters, and financial issues (Alwashmi et al., 2020) as negatively associated with adoption. These studies provide valuable insights into patient attitudes toward mHealth adoption, but less attention has been paid to the perspectives of physicians (Addotey-Delove et al., 2022; Kong et al., 2020; Yoon et al., 2022), despite these professionals being a vital link in treatment pathways for patients (Della Vecchia et al., 2022). Their limited involvement can hinder the success of mHealth apps (Addotey-Delove et al., 2022; Wu et al., 2022). Physicians are often key to driving change in healthcare, substantially influencing the acceptance and adoption of mHealth technologies on the basis of their own usage decisions (Yoon et al., 2022). For instance, physician advocacy for mHealth apps can influence patients' decision to use them, with the latter being more likely to accept and adopt these innovations upon recommendation by healthcare providers (Cajita et al., 2018; Chahal et al., 2021).

Additionally, Dahlhausen et al. (2021) and Li et al. (2021) highlighted a general consensus among physicians on the integration of mHealth apps into standard care and identified barriers to adoption, such as the lack of information and medical evidence, legal concerns, challenges related to patient engagement, and financial implications. However, these researchers focused on developed countries, deriving findings that might not fully be applicable to the context of developing countries. Correspondingly, this translates to a gap in understanding physicians' attitudes toward mHealth adoption on a global scale. This gap was underscored in a recent systematic review conducted by Alsahli et al. (2023), who noted that the majority of research on mHealth acceptance among physicians during the COVID-19 pandemic has been conducted in developed nations. This one-sided concentration is concerning because the dynamics underlying the sociocultural, economic, and healthcare systems in developing countries vary markedly from those in their developed counterparts (Ayukekbong et al., 2017; Bojanic & Tan, 2021). Cultural and contextual factors play a crucial role in the acceptance and adoption of mHealth apps (Deng et al., 2018; Hamidi & Chavoshi, 2018). For example, Saudi Arabia is a religiously and socially conservative country with a high degree of cultural homogeneity stemming from Islamic and tribal affiliations—features that contribute not only to the cultural uniqueness but also to the complexity of the country (Alghamdi & Ernest, 2019; Binsahl et al., 2020). Additionally, given that the majority of the global population resides in developing countries (Arceneaux et al., 2017), investigating mHealth acceptance and adoption factors in these regions improves the applicability and relevance of research findings in the international arena.

3. Theoretical background and hypotheses

3.1. Technology acceptance models and theories

Exploring the determinants that influence technology acceptance is a vital research topic in the field of information technology (Yadegari et al., 2022). Technology acceptance can be defined as constituted by attitudes toward technologies, which are influenced by several factors (Momani, 2020; Yadegari et al., 2022). Such acceptance by users must be evaluated to minimize the chances of failure in the implementation of new technology (Hanaysha, 2022). This evaluation is typically carried out with the help of technology acceptance theories and models, which are instrumental in comprehending the dynamics that underlie adoption or rejection (Yadegari et al., 2022). Over the years, researchers have proposed various theories and models, each offering unique perspectives on technology acceptance. For example, the theory of reasoned action (TRA) emphasizes the importance of individual attitudes and subjective norms in forecasting behavioral intentions (Ajzen & Fishbein, 1980), underscoring the societal and individual motivational factors that influence behavior. The TRA was expanded into the theory of planned behavior (TPB), which includes an additional construct—perceived behavioral control (Ajzen, 1985). This factor refers to an individual's perception of their capability to successfully execute behavior (Ajzen, 1985). It acknowledges that even if individuals have positive attitudes and experience social pressure to adopt a behavior, they may still be constrained by their perceived control over such conduct. Transitioning into the information systems field, the technology acceptance model (TAM) focuses particularly on technology adoption (Davis, 1985). This model is an adaptation of the TRA and TPB, streamlining influencing factors into two primary predictors: perceived usefulness and perceived ease of use (Davis, 1985; Marangunic & Granic, 2015). According to the TAM, a positive attitude toward both usefulness and ease of use leads to an increased intention to use a technology.

In comparison studies of previously proposed theories and models, Venkatesh et al. (2003) identified major limitations, such as the considerable focus of these frameworks on individuals and simple information technologies that do not have the complexity and sophistication of organizational innovations. These theories/models are also substantiated mostly in empirical studies conducted in academic settings, involving students and therefore failing to sufficiently reflect the experiences of practical users (e.g., employees). Finally, these theories and models commonly evaluate technology acceptance in a retroactive manner, rather than during the initial stage of adoption. Addressing these limitations, Venkatesh et al. (2003) refined and integrated disparate technology acceptance models to propose the unified theory of acceptance and use of technology (UTAUT), which is considered the most comprehensive framework for elucidating acceptance and adoption in the field of information systems (Al-Mamary, 2022; Deryl et al., 2023; Hanaysha, 2022; Momani, 2020; Tamilmani et al., 2022). The UTAUT stands out for its robust explanatory power, accounting for up to 70 % of the variances in users' intention to adopt technology, considerably outperforming other models, which explain only 17 % to 53 % of such variances (Alfalah, 2023; Momani, 2020; Sultana, 2020; Venkatesh et al., 2003). The UTAUT emphasizes the influence of performance expectancy (PE), effort expectancy (EE), social influence (SI), and facilitating conditions (FCs) on a user's behavioral intention to accept and use technologies (Venkatesh et al., 2003). It further explains that such acceptance and usage are also affected by individual differences in age, gender, experience, and voluntariness of use. These four measured variables serve as moderators of the relationship between the four basic predictors (PE, EE, SI, and FCs) and the aforementioned intention (Fig. 1).

3.2. The conceptual model

The conceptual model for this study is an adaptation of the unified theory of acceptance and use of technology (UTAUT). The UTAUT is widely recognized for its effectiveness in predicting user acceptance- and usage-related intentions and behaviors toward technology in various contexts (Al-Mamary, 2022; Deryl et al., 2023; Momani, 2020). Given the unique setting of Saudi Arabia, the model was adapted to

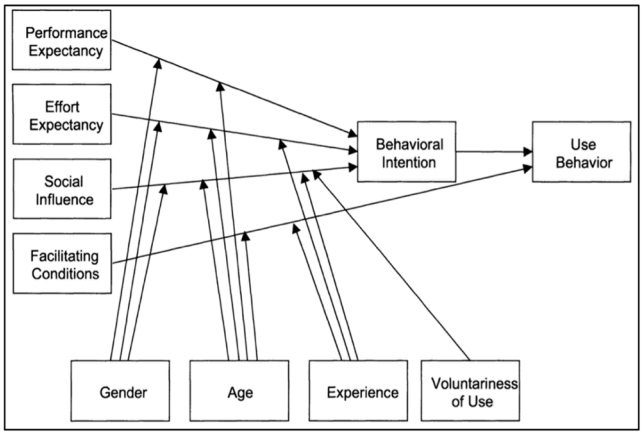

Fig. 1. The unified theory of acceptance and use of technology (Venkatesh et al., 2003).

focus on the core constructs of the UTAUT while considering the sociocultural and technological factors that influence the acceptance and adoption of mHealth apps by physicians. This adaptation involved a targeted examination of how the UTAUT constructs operate in the Saudi healthcare sector, as well as an acknowledgment of the rapid evolution of healthcare technologies and the increasing importance of digital health solutions.

Although there is extensive research on technology adoption models across several industries and global contexts, there is a notable lack of understanding regarding these dynamics, specifically within the healthcare context of developing nations, such as Saudi Arabia. These dynamics include the unique sociocultural influences, technological infrastructure challenges, and the specific behaviors and attitudes of healthcare professionals toward technology adoption. As previously stated, the majority of such studies have concentrated on developed countries or the wider perspectives of patients, frequently neglecting the crucial involvement of healthcare professionals in the process of adoption (Aljohani & Chandran, 2021a; Alsahli et al., 2023; Alsswey et al., 2021). This oversight is critical because these professionals not only serve as primary users but also play a major role in influencing and promoting the adoption of technology in healthcare environments. This deficiency was addressed in the current work by investigating how the adapted UTAUT constructs of PE, EE, SI, and FCs influence Saudi physicians' intention to adopt mHealth technologies and by exploring the moderating effects of demographic variables, such as age, gender, and experience, on these relationships.

The adaptation of the UTAUT model involved retaining behavioral intention but excluding use behavior, which pertains to continuous and routine usage post-acceptance (Wu et al., 2022). According to Venkatesh et al. (2003) a strong behavioral intention toward technology use significantly predicts actual technology usage. However, considering the early stage of mHealth app implementation in Saudi Arabia (Alharbi et al., 2021), the present study focused on examining physicians' behavioral intention instead of their actual usage. Another modification made to the model was the elimination of voluntariness of use as a moderator seeing as this concept determines whether the use of technology is voluntary or mandatory. The use of mHealth apps among the participants of this study was neither strictly required nor purely optional. The constructs used in this research and the adapted hypotheses are discussed in the following sections (Fig. 2).

3.2.1. Performance expectancy (PE)

PE is the extent to which an individual believes that using a system will improve their job performance and advance goal realization (Venkatesh et al., 2003). This belief considerably influences an individual's likelihood of accepting and using an innovation (Alfalah,

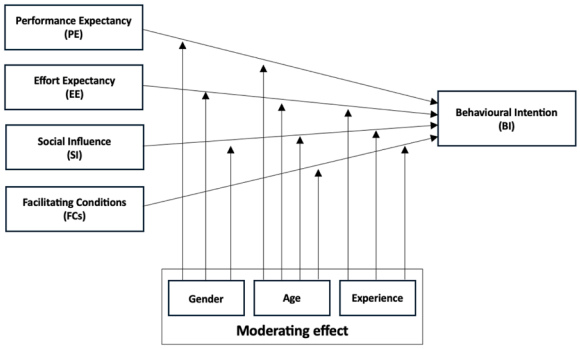

Fig. 2. The conceptual model.

2023; Tian & Wu, 2022; Venkatesh et al., 2003). PE and the behavioral intention to adopt various technologies, including mHealth apps, have been demonstrated in numerous studies as strongly associated with each other (Alam et al., 2020a, 2020b; Octavius & Antonio, 2021; Wu et al., 2022). Considering the vital role of mHealth apps in enhancing healthcare provision, especially during the COVID-19 global outbreak, it is reasonable to anticipate Saudi physicians who see the advantages of these applications in their practice to be predisposed to adopting them. Furthermore, the relationship between PE and behavioral intention is plausibly moderated by age and gender (Gu et al., 2021). For example, young physicians may be technologically adept and demand more from mHealth apps, while gender may affect perceptions of a technology's usefulness. On this basis, the following hypotheses were formulated:

H1. PE is positively associated with physicians' behavioral intention to adopt mHealth applications.

H1a. The impact of PE on behavioral intention is moderated by age and gender.

3.2.2. Effort expectancy (EE)

EE refers to the degree to which an individual considers the use of a system to be easy (Venkatesh et al., 2003), and its importance as a determinant of mHealth technology usage is supported by the literature (Alam et al., 2020b; Wu et al., 2022). In the context of mHealth, physicians are more likely to adopt user-friendly apps that integrate easily into their workflow. This usability, in turn, considerably facilitates adoption, whereas complexity reduces the intention to use technologies (Liu et al., 2022; Tian & Wu, 2022). Furthermore, the association between EE and behavioral intention may be moderated by factors such as age, gender, and experience (Gu et al., 2021). To illustrate, using mHealth apps may be easier for younger male physicians, who are more used to digital tools, and prior experience with similar technologies may also affect EE. Accordingly, the suppositions below were established:

H2. EE is positively associated with physicians' behavioral intention to adopt mHealth applications.

H2a. The impact of EE on behavioral intention is moderated by age, gender, and experience.

3.2.3. Social influence (SI)

SI is defined as the degree to which an individual believes that other people or groups who have the same cultural or social beliefs as they do are key to their decision-making on the acceptance or usage of technology (Venkatesh et al., 2003). In a collectivist culture such as Saudi Arabia, individuals tend to prioritize the demands and expectations of the collective, such as their families, communities, or tribes, over their own personal desires (Alotaibi & Campbell, 2022). As a result, physicians are more inclined to implement mHealth apps in their practice if the community regards them as advantageous. Research has

demonstrated that SI is strongly associated with a user's intention to use technology (Alam et al., 2020a, 2020b; Wu et al., 2022). Furthermore, younger, male, and more experienced physicians may be more susceptible to SI, which potentially moderates the aforementioned association (Gu et al., 2021). With consideration for this matter, we put forward the following:

H3. SI is positively associated with physicians' behavioral intention to adopt mHealth applications.

H3a. The impact of SI on behavioral intention is moderated by age, gender, and experience.

3.2.4. Facilitating conditions (FCs)

FCs pertain to the extent to which an individual believes that an existing organizational and technical infrastructure supports the use of a new system (Venkatesh et al., 2003). In light of the nascency of mHealth app implementation in Saudi Arabia, the presence of FCs is critical in promoting adoption by physicians. Such practitioners tend to use mHealth apps if they are convinced that they have sufficient support for adoption in terms of organizational policy, technological resources, and training opportunities (Wu et al., 2022). As with the three other predictors, the relationship between FCs and behavioral intention may be moderated by age and experience, with younger physicians and those with less experience possibly relying more heavily on supportive infrastructure to promote their adoption of mHealth apps (Gu et al., 2021). This led us to establish Hypotheses 4 and 4a:

H4. FCs are positively linked to physicians' behavioral intention to adopt mHealth applications.

H4a. The impact of FCs on behavioral intention is moderated by age and experience.

4. Methodology

4.1. Research approach and design

This study administered a cross-sectional survey to Saudi physicians to capture their intentions regarding the acceptance and adoption of mHealth apps. This method was chosen because it involves the use of statistical analysis techniques that enable the derivation of conclusions and generalizations about a population (Baran & Jones, 2016; Creswell & Creswell, 2018). This research was granted approval by the ethics committee of the University of Technology Sydney (UTS HREC REF NO. ETH21-6751).

4.2. Sampling and data collection

Online surveys are considered an effective way of reaching respondents amid the COVID-19 pandemic, during which face-to-face surveys would have contravened social distancing rules (Yaprak et al., 2021). Accordingly, online administration was selected as the method of data collection in this work. Before survey distribution during the research proper, a pilot study was conducted involving 30 randomly chosen physicians, who were tasked with validating the survey instrument. The feedback obtained thus was used to make adjustments to the survey. For the main study, simple random sampling was carried out to ensure that each Saudi physician had an equal opportunity to participate, to minimize selection bias, and to enhance the generalizability of the findings (Baran & Jones, 2016). The inclusion criterion was Saudi physicians practicing in Saudi Arabia, while the exclusion criterion was non-Saudi physicians. The appropriate sample size was determined following Kline's recommendation of a minimum of 200 respondents for structural equation modeling (SEM) to ensure the statistical robustness and reliability of model estimates (Kline, 2015). The online survey was then made available over the Qualtrics platform via a link distributed to the eligible physicians by email with assistance from the Saudi Arabia Ministry of Health and Saudi medical societies. Reminder emails were sent every three weeks to maximize response rates and encourage participation. Data were collected from December 2022 to May 2023. To ensure the accuracy and integrity of the data, the survey platform was configured to permit only one submission per respondent and to include checks for inconsistent responses. The data were encrypted and securely stored to ensure confidentiality and adherence to ethical standards.

4.3. Measurement

The survey instrument was grounded in the UTAUT, which is a well-established standardized tool for assessing the factors that influence the acceptance and adoption of technology (Alam et al., 2020a; Aljohani & Chandran, 2021b). The survey included an information sheet that describes the research aim, contains the researchers' contacts detail, and a consent form. The start of the survey included a definition and description of mHealth apps to clarify awareness of the technology of interest for participants. The survey is divided into three main sections, among which the first revolves around demographic characteristics, including gender, age, and specialization. The second section is intended to derive additional details on the participants' awareness of mHealth implementation in Saudi Arabia. It includes questions about the use of mHealth, years of experience, and the type of mHealth services that the physicians have used. The third section consists of items centered on UTAUT factors that may influence the acceptance and adoption of mHealth apps. It also includes statements related to the dependent variable (behavioral intention). Each variable is described in four statements, to which the participants were asked to respond using a five-point Likert scale (1 = *strongly disagree*, 5 = *strongly agree*).

4.4. Data analysis

The data were analyzed using the Statistical Package for the Social Sciences (SPSS) 28, along with its supplementary software AMOS 28. Structural equation modeling (SEM) was conducted using the two-step approach recommended by Anderson and Gerbing (1988). This approach underlines the importance of validating the measurement model before assessing the structural model, ensuring that the constructs are measured accurately before testing the relationships among them.

5. Results

5.1. Demographic characteristics

The demographic information on the respondents is shown in Table 1. The study involved a diverse group of participants, who were mainly males (59.8 %) and general practitioners (71 %). The largest age group was between 31 and 40 years (48.8 %). The majority were familiar with mHealth apps (84.1 %), with 77.1 % having used them primarily for personal use (60.3 %) and online consultations (18.9 %).

5.2. Assessment of the measurement model

The reliability and convergent validity of the research constructs were evaluated using Cronbach's alpha values, composite reliability (CR), average variance extracted (AVE), and factor loadings in accordance with established quality standards. Recommendations are for Cronbach's alpha and CR to be 0.70 or higher, while factor loadings and the AVE value should be 0.5 or above (Creswell & Creswell, 2018; Fornell & Larcker, 1981; Hair et al., 2018; Siri et al., 2020). As illustrated in Table 2, the values derived in this study exceed the acceptable levels.

The study also assessed discriminant validity using the criterion of Fornell and Larcker (1981), which suggests that discriminant validity is established if the square root of the AVE is greater than the correlation between a given construct and any other construct. Table 3 confirms that

Table 1
Demographic profile of the participants.

Items	Frequency (N = 428)	(%)
Gender		
Male	256	59.8
Female	172	40.2
Age (years)		
25–30	73	17.1
31–40	209	48.8
41–50	85	19.9
51–60	61	14.2
What is your specialization?		
General practitioner (G.P.)	304	71
Internal medicine	43	10
Surgery	17	4
Pediatrics	34	8
Other	30	7
Have you heard about the implementation of mobile health applications (mHealth apps) in Saudi Arabia?		
Yes	360	84.1
No	68	15.9
Have you used mHealth apps before?		
Yes	330	77.1
No	98	22.9
How many years have you been using it?		
Never use	68	15.9
1–2 years	214	50
3–4 years	146	34.1
What type of mHealth services have you used?		
Providing online consultations	81	18.9
Creating e-prescriptions	21	4.9
Personal use	258	60.3
Never use	68	15.9

Table 2
Measurement model.

Constructs	Items	Factor loadings	Cronbach's alpha	CR	AVE
PE	PE1	0.682	0.808	0.809	0.514
	PE2	0.714			
	PE3	0.764			
	PE4	0.706			
EE	EE1	0.653	0.799	0.800	0.501
	EE2	0.723			
	EE3	0.722			
	EE4	0.731			
SI	SI1	0.639	0.801	0.802	0.504
	SI2	0.720			
	SI3	0.764			
	SI4	0.712			
FC	FC1	0.669	0.815	0.818	0.530
	FC2	0.731			
	FC3	0.718			
	FC4	0.789			
BI	BI1	0.737	0.792	0.792	0.560
	BI2	0.758			
	BI3	0.749			

Table 3
Discriminant validity.

Latent variables	PE	EE	SI	FC	BI
1. PE	**0.717**				
2. EE	0.646	**0.708**			
3. SI	0.666	0.628	**0.710**		
4. FC	0.614	0.560	0.595	**0.728**	
5. BI	0.575	0.574	0.588	0.567	**0.748**

all diagonal values (square root of AVE) exceed the correlations among the constructs, affirming their discriminant validity.

Subsequent to these assessments, the model's goodness-of-fit indices were scrutinized using AMOS (Collier, 2020). Table 4 summarizes the outcomes for the primary fit measures, including the recommended and observed values for each measure. The results indicated that all observed values fall within the recommended ranges, suggesting an adequate fit of the structural model (Fig. 3).

Table 4
Model fit (goodness-of-fit indicators).

Fit index	Recommended value	Observed value	Fit (yes/no)
X2/DF	1–5	1.637	Yes
CFI	>0.90	0.972	Yes
IFI	>0.90	0.972	Yes
TLI	>0.90	0.966	Yes
RMSEA	<0.08	0.039	Yes
SRMR	<0.08	0.035	Yes

5.3. Assessment of the structural model

The structural model was used to test the research hypotheses. As presented in Table 5, all paths hypothesized in the study are statistically significant. The results demonstrated that performance expectancy is positively impact on physicians' behavioral intention to adopt mHealth apps (b = 0.147, t = 2.579, p = 0.004), thereby supporting H1. A significant positive association was found between effort expectancy and the physicians' behavioral intention to adopt mHealth apps (b = 0.232, t = 4.936, p = <0.0001), thus supporting H2. A statistically significant relationship between social influence and the physicians' behavioral intention to adopt mHealth apps was found (b = 0.240, t = 4.615, p = <0.0001), confirming H3. Also, the impact of facilitating conditions on physicians' behavioral intention was positive and significant (b = 0.242, t = 5.628, p = <0.0001), translating to support for H4. Notably, facilitating conditions exert the most substantial influence on the physicians' behavioral intention to accept mHealth apps. The combination of the four factors (PE, EE, SI, FCs) explains 58 % of the variance in behavioral intention (R^2 = 0.58) as shown in Fig. 4.

5.4. Moderating effects

We carried out a moderation analysis to delve into the effects of gender, age, and experience using the multigroup analytical function in AMOS. The comparison of unconstrained and fully constrained models revealed no statistically significant variations in the chi-square values, indicating that these factors do not moderate the studied relationships (Table 6). All significant and non-significant paths are depicted in Fig. 5.

6. Discussion

To the best of our knowledge, this study is the first to examine physicians' acceptance and adoption of mHealth apps in Saudi Arabia during the COVID-19 pandemic on the basis of the UTAUT. This distinction is vital, as it not only addresses a gap in the literature but also offers a foundational understanding of the factors influencing mHealth adoption during a critical period—a global health crisis—in a developing country. By leveraging the UTAUT, our research delivers insights into the behavioral intention of physicians to use mHealth apps, with consideration for the unique sociocultural and technological environment of Saudi Arabia.

The first hypothesis suggests that performance expectancy is positively associated with the behavioral intention of physicians to adopt mHealth apps. This supposition was supported by the findings, demonstrating that Saudi physicians who have a strong belief in the effectiveness of mHealth apps in enhancing their professional performance are motivated to use them. The importance of efficient and effective healthcare delivery was magnified in the Saudi Arabian context during the COVID-19 pandemic, during which the country's healthcare system faced considerable pressure. It highlights the critical role of performance expectancy in the adoption of mHealth apps. The findings

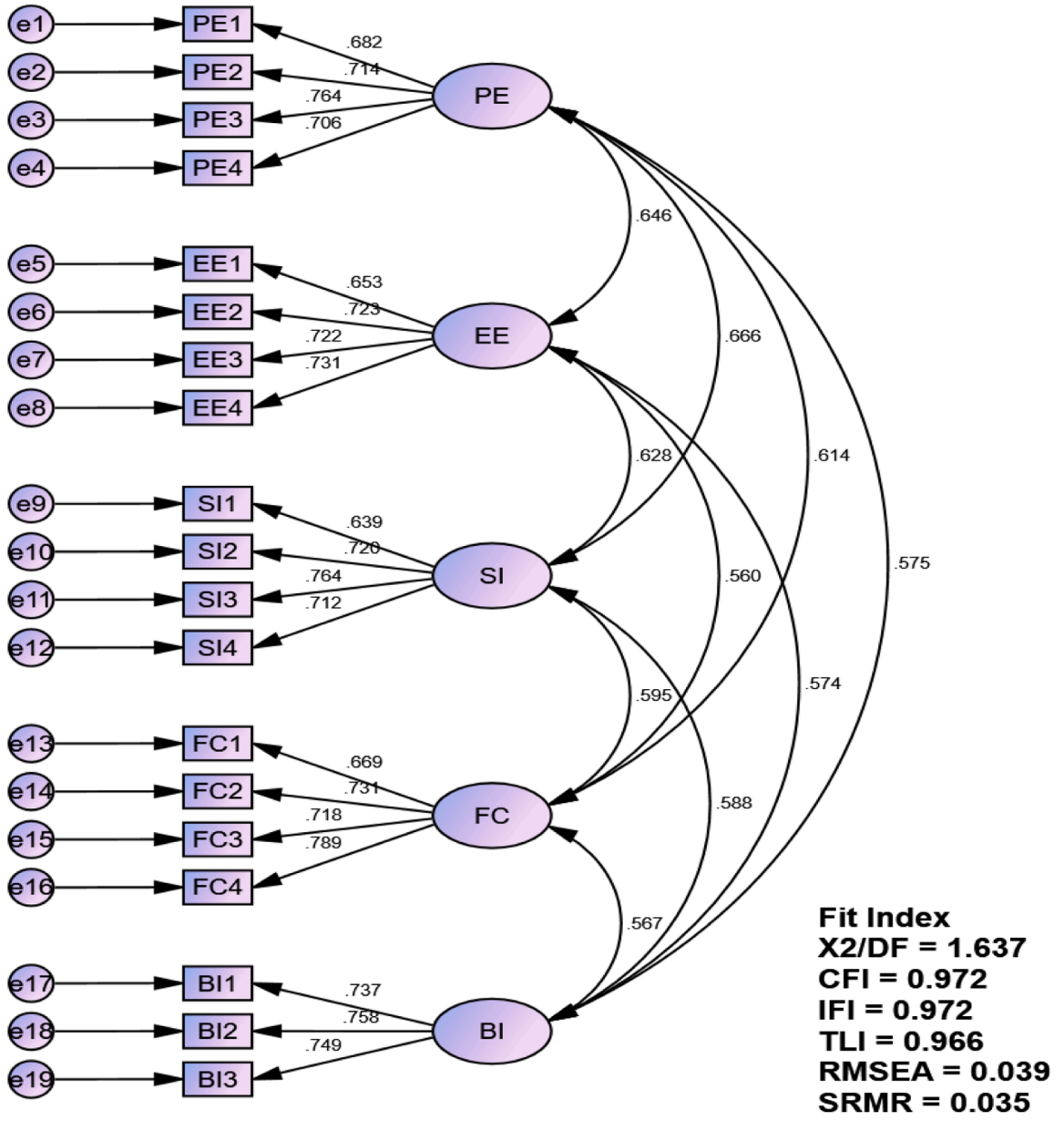

Fig. 3. The Measurement model.

Table 5
Summary of results on structural relationships.

Hypothesis	Structural path	SRW	Std. error	*t*-value	*p*-value	Result
H1	PE -> BI	0.147	0.057	2.579	0.004	Accepted
H1	EE -> BI	0.232	0.047	4.936	<0.0001	Accepted
H3	SI -> BI	0.240	0.052	4.615	<0.0001	Accepted
H4	FC -> BI	0.242	0.043	5.628	<0.0001	Accepted

are also consistent with the results of prior studies (Alfalah, 2023; Edo et al., 2023; Octavius & Antonio, 2021; Venkatesh et al., 2003; Wu et al., 2022). More specifically, Wu et al. (2022) showed that physicians believe mHealth extensively improves their jobs by helping them save time and effort as they deliver healthcare services to patients.

Our second hypothesis posits that effort expectancy favorably influences physicians' behavioral intention to use mHealth apps. This hypothesis was supported, indicating that ease of use is a critical factor for technology acceptance. In the context of Saudi Arabia, physicians are tremendously more likely to use mHealth apps when they believe that their integration into their routine practices and existing workflows is a smooth undertaking, that is, involving slight changes to the status quo. This finding aligns with those of previous studies, which suggested that users are motivated to adopt user-friendly mHealth apps (Al-Mamary, 2022; Deng et al., 2018; Wu et al., 2022).

The third hypothesis maintains that social influence positively impacts physicians' behavioral intentions. This hypothesis was also confirmed, demonstrating that the opinions of colleagues and cultural contexts remarkably affect mHealth app adoption among physicians in Saudi Arabia. This result highlights the essentiality of social norms and collective beliefs in the healthcare community of Saudi Arabia, where individual decision-making is heavily influenced by consensus in one's social and professional networks. In contrast to the findings of Edo et al. (2023), who found that social influence has no significant impact on digital health technology adoption among healthcare workers, our results demonstrated the meaningful role of social dynamics in Saudi Arabia. This difference can be explained by the collectivist culture prevalent in Saudi Arabia, where the expectations of the collective (e.g.,

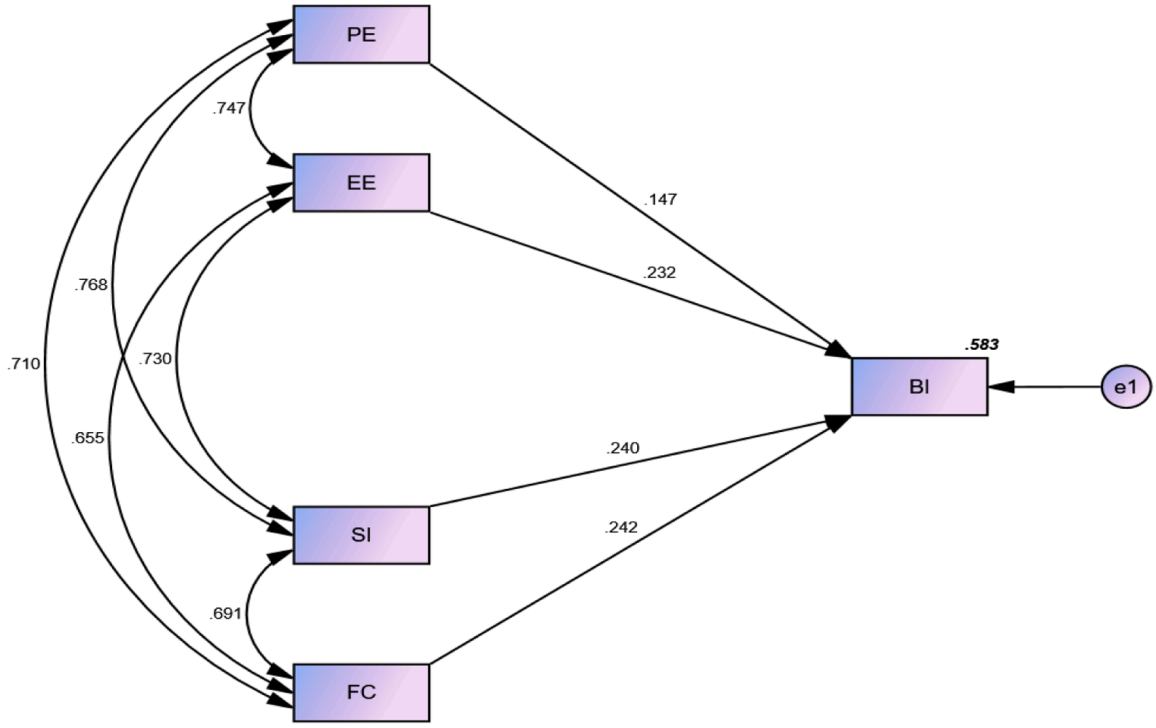

Fig. 4. The structural model.

Table 6
Overall analysis of moderators.

Moderators	Models	X^2	df	CFI	χ^2/df	χ^2 Difference	*p*-value
Gender	Unconstrained	351.531	284	0.979	1.238	34.258	0.598
	Fully constrained	385.789	321	0.979	1.202		
Age	Unconstrained	859.601	702	0.955	1.225	37.000	0.140
	Fully constrained	905.928	739	0.952	1.226		
Experience	Unconstrained	625.305	493	0.959	1.268	45.110	0.169
	Fully constrained	670.415	530	0.957	1.265		

families, communities, colleagues, or tribes) often come before individual desires (Alotaibi & Campbell, 2022). Our findings parallel those of previous research on mHealth acceptance (Alam et al., 2020a; Wu et al., 2022), which implied that recommendations from colleagues, the views of peers, and the general social context surrounding a medical community exert an essential influence on the behavioral intention to use mHealth innovations.

The final hypothesis, which proposes that facilitating conditions are positively linked to the adoption of mHealth apps, was supported, implying that having a supportive technological and organizational infrastructure is instrumental in the acceptance and implementation of mHealth apps among Saudi physicians. This finding is in line with the research conducted by Wu et al. (2022), who demonstrated that these technologies cannot be used in mainstream medical practice until a comprehensive system that encompasses infrastructure and training programs is established. Healthcare organizations that support the use of technological components and the provision of educational programs are vital facilitators of the use of these innovations.

In addition, the current study examined the potential moderating effects of gender, age, and experience on the associations between the four primary constructs (performance expectancy, effort expectancy, social influence, and facilitating conditions) and the behavioral intention of physicians to use mHealth apps. The results led us to conclude that gender, age group, and experience exert nonsignificant moderation effects on the physicians' behavioral intention to use mHealth apps. Our findings contradict those reported by Gu et al. (2021), who found that demographic factors significantly moderate the associations between the UTAUT factors and user adoption of e-health technologies. This difference may be ascribed to the uniformity of the healthcare system and education standards in Saudi Arabia, which perhaps leads to comparable familiarity with mHealth apps among physicians. It is also possible that rapid advancements in technology and the government efforts implemented during the COVID-19 pandemic have reduced typical demographic barriers, as these situations compelled physicians of all backgrounds to embrace new technologies.

The results of this research likewise pinpointed notable differences in the determinants of mHealth app implementation between physicians in Saudi Arabia and their peers in other countries (Edo et al., 2023; Gu et al., 2021). For instance, the importance of social influence in our study contrasts with the results derived in cultures that prioritize individualism, where personal independence may be more important than collective opinions when making decisions about adopting technology (Edo et al., 2023). This difference highlights the import of cultural norms in influencing attitudes toward technology adoption. It also implies that successful implementation is not universal and that applicability in other regions requires adjustment to local contexts. Furthermore, the lack of moderation by age, gender, and experience in our study indicates remarkable homogeneity in the acceptance of technology among Saudi physicians. This may be attributed to national policies and educational standards that differ from those in other countries. These contrasts offer crucial insights for global health technology strategists, emphasizing the need for tailored mHealth

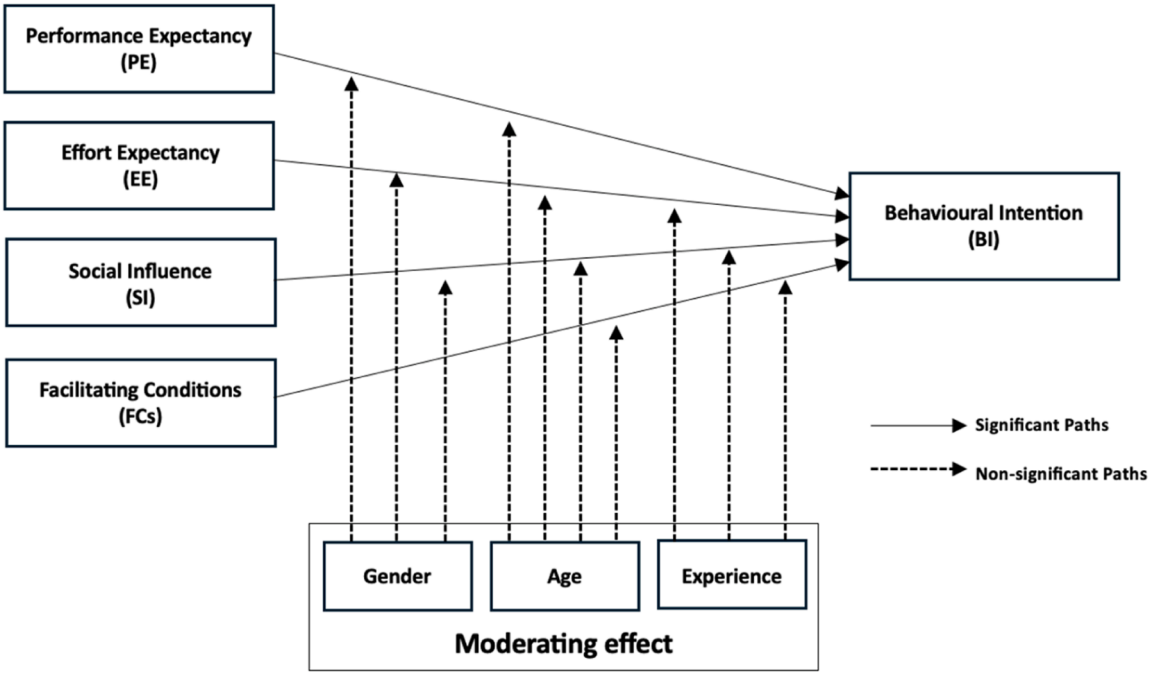

Fig. 5. Results of path analysis.

implementation policies to suit the particular cultural, infrastructural, and policy circumstances of each region to maximize acceptance and effectiveness. Our comparative analysis strengthens the importance of context in the development and deployment of technological innovations in healthcare and enhances our comprehension of global technology adoption patterns.

6.1. Theoretical implications

This study offers important contributions to the theories underlying technology acceptance models, particularly focusing on healthcare sector in developing countries. The UTAUT was used to examine the acceptance and adoption of mHealth apps by Saudi physicians during the COVID-19 pandemic, thus extending the traditional boundaries to which the theory has hitherto been applied. The UTAUT has been previously associated mainly with developed nations and the broader technological environment, but its deployment in the specific, emergent context of Saudi Arabia not only validated the model's robustness and adaptability but also highlighted its relevance and efficacy in dynamic and crisis-driven settings. Furthermore, it illustrated the UTAUT's considerable effectiveness in predicting behavioral intentions amid rapid technological development and challenges to healthcare services beyond the settings for which it was originally developed. This predictive effectiveness extensively broadens the scope of the UTAUT, emphasizing its potential applicability across a diverse range of situations beyond those previously considered. This expansion is particularly pertinent, as it illustrates the model's utility in understanding and predicting technology acceptance in less-studied, rapidly evolving environments.

The adaptation of the UTAUT model also enabled a more accurate reflection of contexts in which cultural elements could considerably influence technology acceptance. The adjustments carried out in this research rendered the model more sensitive to the features of local culture and the limitations imposed by existing infrastructure. Therefore, the adaptation more effectively advanced a nuanced understanding of the dynamics underlying technology acceptance in a specific context. This tailored approach reflects the importance of considering local realities that shape the use and acceptance of technology, thus adding to the depth of the theoretical understanding of technology adoption. Furthermore, since Saudi Arabia is essentially a collectivist society, as opposed to the individualist Western context, this study expands the academic discussion of the societal values and social dynamics that influence technology acceptance. From this point of view, this research encourages the further expansion of the UTAUT by adding variables that specifically target cultural dimensions. In this way, the model could be refined to more accurately reflect a variety of cultural contexts and improve its prediction of technology acceptance behaviors in these settings. Such broadening of the model's theoretical and practical relevance could lead to more effective and culturally tailored strategies for technology implementation, ultimately enhancing the adoption and integration of technology globally.

6.2. Practical implications

The results also offer valuable insights to stakeholders in healthcare sectors, especially in countries similar to Saudi Arabia, where technology adoption is considerably influenced by cultural factors and infrastructural conditions. This study highlights the critical need for healthcare policymakers and managers to address infrastructural needs and take complex sociocultural dynamics into account when planning and implementing strategies for the effective integration and acceptance of mHealth applications. In particular, this research emphasizes the essential role of facilitating conditions, such as organizational support and training assistance, in technology acceptance and adoption. Thus, it is important for policymakers to strategize significant investments in IT that support healthcare services. Comprehensive training programs designed to meet the specialized demands of healthcare professionals should also be established. These programs should exemplify the practical benefits of mHealth apps alongside the development of the skills necessary for physicians to effectively utilize the technologies involved. These initiatives would not only drive the awareness of healthcare providers regarding the full potential of mHealth solutions but also develop the proficiency that they need to realize this potential. Both infrastructural resources and user training are prerequisites for the optimal effectiveness of mHealth technologies.

Additionally, the importance of social influence dynamics,

particularly in a collectivist culture such as Saudi Arabia, cannot be overstated. To take advantage of these dynamics, promotional strategies for mHealth app usage should, for example, include endorsements by respected professionals and influencers within medical communities. Successful case studies and peer testimonials can be leveraged in dedicated promotional programs to effectively harness social influence, leading to considerably enhanced adoption rates. This strategic approach underscores the practical benefits of mHealth apps and highlights their acceptance and effectiveness in the healthcare community so that they become more broadly integrated into everyday healthcare practices. This holistic strategy likewise ensures the successful introduction of mHealth technologies and their continued integration and effective use. The findings are equally beneficial for developers of mHealth applications, enabling them to design user-friendly applications that also align with the professional expectations and accepted practices of healthcare providers. It is crucial for developers to focus on seamless integration into existing workflows while adding features that enhance job performance so as to encourage adoption by practitioners. Such an approach will not only guarantee the creation of fully functional apps but also ultimately make them indispensable tools for healthcare professionals.

6.3. Limitations and directions for future research

This research used the UTAUT to elucidate the acceptance of mHealth apps by physicians in Saudi Arabia during the COVID-19 pandemic. As with any other research, ours was encumbered by certain limitations that also translate to opportunities for future research. First, although the UTAUT is a comprehensive framework, it might not completely capture all the unique factors influencing mHealth app acceptability during the COVID-19 pandemic. For example, physicians may have faced unique stresses and rapidly changing healthcare regulations, which could have affected their adoption behaviors in ways not fully accounted for by the theory. Second, the selection of Saudi Arabia as the sole context for investigation potentially hinders the generalizability of the results to other countries. This specific setting offers unique perspectives, but cultural, infrastructural, and regulatory disparities restrict generalizability. Moreover, while our data analysis confirmed our hypotheses, the use of the survey method constrained our ability to delve into the complexities and nuanced perspectives of physicians. The survey format inherently limits the extent of responses and may fail to consider subtle yet crucial elements of user experience and personal decision-making processes. Finally, this study employed a multigroup analysis to examine the moderating effects of gender, age, and experience on mHealth adoption among Saudi physicians, revealing evidence of moderation effects. Moderation effects typically require a large sample size to detect, with our study we are likely detect only very large, e.g. cross-over moderation effects where the association in one group is large and opposite to the other group. It is not considered that the results from this study can be interpreted as definitive evidence that such effects do not exist.

Future research can benefit from integrating qualitative approaches, such as interviews or case studies, as this would advance a more exhaustive understanding of the individual and contextual factors that influence the acceptance of or resistance to mHealth technologies. Longitudinal studies can also cast light on the evolution of physicians' usage and attitudes toward mHealth applications as they adjust to ongoing transformations in their professional and regulatory environments. By expanding the scope of the research to involve other countries, future studies can uncover region-specific challenges and opportunities, thus enhancing the practical application of mHealth technologies in a wide range of healthcare settings. Finally, future research investigating the potential moderating effects of gender, age, and experience should consider a larger sample size and collecting data with more diversity in cultural or healthcare contexts. Conducting such research would not only confirm or challenge our findings but also enhance our understanding of the factors that impact the uptake of mHealth technologies.

7. Conclusion

This study employed the UTAUT to analyze the factors that drive the acceptance and use of mHealth apps by Saudi physicians amid the COVID-19 pandemic. The study uncovered that all the four major constructs of the model—performance expectancy, effort expectancy, social influence, and facilitating conditions—exerted a significant influence on Saudi Arabian physicians' behavioral intention to use mHealth technologies. In particular, facilitating conditions, such as organizational support and training assistance, emerged as the strongest predictors of Saudi physicians' intention to adopt mHealth apps. This finding punctuates the necessity of investing in infrastructure and implementing training programs focused on integrating mHealth technology into medical practice. Compared with existing studies, which mainly focus on developed countries, the current work unraveled the dynamics of mHealth acceptance and adoption in developing nations. The observations derived point to the fact that although personal perceptions about the usefulness and simplicity of technology are crucial factors, the collective influence of social influence and organizational support is paramount in a collectivist culture such as Saudi Arabia's. By addressing these specific factors, healthcare stakeholders can better plan the implementation of digital health solutions to enhance service delivery and patient outcomes during health crises and beyond.

CRediT authorship contribution statement

Sultan Alsahli: Writing – review & editing, Methodology, Investigation, Conceptualization. **Su-yin Hor:** Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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