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ARTICLE

Older people's intention to use medical apps during the COVID-19 pandemic in China: an application of the Unified Theory of Acceptance and Use of Technology (UTAUT) model and the Technology of Acceptance Model (TAM)

Yin Ma[1] and Muyuan Luo[2]*

[1]School of Philosophy and Sociology, Lanzhou University, Lanzhou, China and [2]Research Institute of Social Development, Southwestern University of Finance and Economics, Chengdu, China
*Corresponding author. Email: luo_muyuan@sina.com

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Abstract

Previous studies on older adults' intention to adopt medical apps during irregular circumstances like the COVID-19 outbreak are still in its infancy. In order to fill this knowledge gap, we developed a theoretical framework based on the Unified Theory of Acceptance and Use of Technology (UTAUT) model and the Technology of Acceptance Model (TAM) to explain Chinese older people's willingness to use medical apps during the COVID-19 pandemic. We collected 1,318 online questionnaires during the first wave of the pandemic in China in early 2020. We employed structural equation modelling to analyse the data, and the results show that (a) attitudes towards using apps influence older people's intention to use apps significantly; (b) only two factors, *perceived usefulness* and *facilitating conditions*, which were proposed in the UTAUT model, significantly predicted the older adults' intention to use apps, but not others; and (c) perceived usefulness, perceived ease of use, subjective norm and facilitating conditions all significantly impact attitudes towards using apps. Further mediation analysis found that attitudes towards using apps significantly mediated the paths suggested in the original UTAUT model. Due to the online survey method we used, older people who do not use the internet were excluded from our sampling process. However, our timely research contributes to the existing literature by showcasing older people's usage of eHealth technology in public health emergencies. It also builds on the broader discussions on technology use by combining the TAM and the UTAUT model, highlighting the vital role of people's attitude towards using technology in shaping their intention to use it.

Keywords: Technology of Acceptance Model (TAM); COVID-19; China; Unified Theory of Acceptance and Use of Technology (UTAUT) model; medical app; senior citizens

Introduction

The COVID-19 pandemic has not only dramatically changed the world we are living in but also exacerbated health inequality among different groups of people that has been covered up by the economic prosperity that we have achieved in the past several decades (Takian *et al.*, 2020). Under such circumstances, the development of telehealth, eHealth or mHealth, which, simply speaking, refers to 'health care carried out at a distance' with the help of technologies, especially the internet (Wootton, 1995), is believed to be an important tool to provide solutions to the health inequality that is partially caused by the unevenly distributed resources of health care (Hussain *et al.*, 2015; Vancea and Solé-Casals, 2016).

The recent development of medical applications best exemplifies this. With the worldwide proliferation of smartphones, there has been a dramatic increase in medical and health-care mobile applications. According to a commercial report, there were more than 165,000 apps developed by 45,000 app publishers in 2015, the total market value of which was estimated to be US $10.2 billion (Research2Guidance, 2015: 3). However, it is noteworthy that, despite a steady increase in internet use among older people, the digital gap remains between older adults and other age groups in the world, especially in non-Western countries (Cole *et al.*, 2017: 23, 2018: 19).

This perfectly demonstrates the importance of technology in the so-called Fourth Industrial Revolution gradually taking shape in the past two decades. This emerging trend is characterised by a fusion of technologies blurring the lines between the physical, digital and biological spheres (Schwab, 2016: 12). A combination of the internet and traditional industries constitutes one of the main features of the Fourth Industrial Revolution, under which the internet is growing rapidly as an industry and reshaping all the traditional industries (Shao, 2015: 225–256). This trend has been further intensified under the COVID-19 pandemic. However, the advancements of the internet and its incorporation into the traditional industries do not necessarily challenge the multiple forms of digital inequalities. Instead, people with limited knowledge of and/or access to the internet will be further marginalised in the new age. Among these different groups, older people deserve our special attention.

Ageing is a problem faced by almost every country in the world, which, for developed and developing countries alike, is believed to have profound influences on and bring tremendous challenges for a country's economic progress, social welfare system and medical system (Díaz-Giménezab and Díaz-Saavedrac, 2009; Manson and Lee, 2011; Rudnicka *et al.*, 2020; Nagarajan *et al.*, 2021). However, the older people with the greatest health needs also tend to be those with the least access to the resources that might help them, which has posed great challenges for policy makers and service providers (World Health Organization, 2017: 3). This is especially true in the context of the COVID-19 pandemic. While existing literature illustrates how the pandemic motivates different countries to focus on the potential of telehealth (Fisk *et al.*, 2020), we still know little about the willingness of older adults to use medical apps during the COVID-19 pandemic.

For several reasons, an investigation of the Chinese case provides fertile ground for studying older people's intention to use medical apps during the COVID-19

pandemic. First, according to the World Health Organization, China is ageing much faster than many other high-income or low- and middle- income countries. The official statistics show that there were 253.8 million people aged 60 years or over (18.1% of the whole population) in 2019, which is expected to increase to 402 million (28% of the entire population) in 2040. One major concern about ageing is the associated increase in the burden of chronic disease. In 2013, of the 202 million older people aged 60 or over in China, more than 100 million had at least one chronic non-communicable disease. By 2030, there will be three times more people living with at least one chronic disease (World Health Organization, 2015: 1–4). As one of the fastest ageing countries with one of the largest aged populations in the world, China constitutes a good starting point to examine technology use among the older population in an ageing context.

Second, the rise of an ageing society has emerged concurrently with the popularity of internet use in China (Guo *et al*., 2019). The number of Chinese netizens reached 989 million in December 2020, with a penetration rate of 70.4 per cent. If it keeps growing at this rate, the number of Chinese netizens will exceed 1 billion in the first half of 2021, accounting for 69.4 per cent of the total population (*Beijing Youth Daily*, 2021). Although senior citizens have become an important part of the internet consumer population in China, only 20 per cent of them have access to the internet. Basic operations, such as downloading and using apps, are still one of the biggest obstacles to using mobile devices for them (Tencent, 2018). When encountering difficulties in online shopping, 50 per cent of them will give up (*People's Daily Online*, 2020). For most of them, the internet is a new thing that only appeared when they entered middle or old age. Therefore, learning to use the internet is challenging for them (Chen, 2017), especially when seeking online medical services (Zhou *et al*., 2021). The tension between China's fast-ageing population and the reluctance of the Chinese older population to use the internet for health services makes China an ideal case to investigate older people's willingness to use medical apps in a context where the population is rapidly ageing.

Third, the pandemic outbreak has increased older people's exposure to the internet and their demand for it. Statistics have shown that the proportion of older users who registered and used the food-ordering website Elema increased significantly. The number of older adults who began to use the internet during this period also far exceeded the number in other age groups (*People's Daily Online*, 2020). Moreover, the pandemic encouraged them to use medical apps instead of in-person services (Zhou *et al*., 2021), especially during and after the Chinese Spring Festival (from late January to February 2020), when people were forcibly quarantined at home. As such, an examination of Chinese older people's intention to use medical apps during this period serves our research purpose perfectly.

Building on the research background presented above, this research demonstrates older people's willingness to use medical apps during the COVID-19 pandemic in China. Following an analysis of 1,318 questionnaires distributed online in the early stages of the pandemic (February 2020), we combined the Technology of Acceptance Model (TAM; Davis, 1989) and the Unified Theory of Acceptance and Use of Technology model (UTAUT model; Venkatesh *et al*., 2003) in our analysis to better capture the participants' intention to use medical apps with the users' attitudes as the important mediator. We then tested this

model during the COVID-19 pandemic. We believe our findings also have implications for meeting older people's needs in the Fourth Industrial Revolution, partially characterised by the incorporating information technology into the traditional industries (Schwab, 2016).

Literature review and hypotheses development

Usage of medical apps among older people

Previous studies employed multiple research methods in investigating senior citizens' intention to use medical apps. Some studies adopted qualitative methods, such as focus group discussions (Parker *et al*., 2013) or semi-structured interviews (Byambasuren *et al*., 2020) to understand the older people's willingness to use medical apps. For example, Parker *et al*. (2013) found that older people in New York City showed great interest in using medical apps. In this research, facilitators include professional training before using devices and tailoring services to the needs of older adults, and the barriers are the cost and a lack of familiarity with the devices. Similarly, Byambasuren *et al*. (2020) found that, despite the ubiquity of electronic devices and doctors' recommendations of apps, older adults were still concerned about the usability of medical apps.

Others studies employed quantitative methods, such as structural equation models (Guo *et al*., 2013; Hoque and Sorwar, 2017; Lan *et al*., 2020) and regressions (Askari *et al*., 2020) to identify the factors that may influence older people's choices. Based on different theories and models (*e.g.* UTAUT or UTAUT2 and trust transfer models), factors such as ease of use, usefulness, social influence, facilitating condition, social trust and technological anxiety have been tested. However, there is also inconsistency in the research findings. For example, in the research of Askari *et al*. (2020), facilitating conditions significantly impacted the older people's adoption intentions, but not others (Hoque and Sorwar, 2017; Lan *et al*., 2020).

Despite the contributions these studies have made to our understanding of older people's needs in the development of eHealth, our knowledge about the potential mechanism contributing to their adoption intention is still in its infancy. Further, we still know little about how these identified factors work during irregular circumstances like the COVID-19 outbreak, which juxtaposes a forced spatial restriction and a relative lack of medical resources. This article fills this gap by investigating the situation in China during the pandemic.

Theoretical framework

We developed our theoretical framework based on the TAM (Davis, 1989) and UTAUT model (Venkatesh *et al*., 2003). The UTAUT model is an integrated model consisting of eight theories commonly utilised in behavioural research and user technological acceptance research. It has been widely applied in various cultural settings, such as North America (Serbern, 2014), South America (Thomas *et al*., 2014), Europe (Nuq and Aubert, 2013), Asia (Isaac *et al*., 2019), sub-Saharan Africa (Karuri *et al*., 2013), and the Middle East and North Africa (Nassuora, 2013), and in diverse technological contexts, such as mobile payment

(Khalilzadeh *et al*., 2017), mobile learning (Ye *et al*., 2020), social media (He *et al*., 2020) and electronic medical applications (Hwang *et al*., 2019) since its release.

Although the UTAUT model excels at explaining users' intention to use information technology, it has been criticised for its lack of attention to users' attitudes to the technology, such as customer satisfaction (Isaac *et al*., 2019). As Montesdioca and Macada (2015), among others, have argued, users' satisfaction, or the so-called performance effect, has played a significant role in the success of the Information System. Following this, this research aims to add users' satisfaction to the original UTAUT model to analyse the older adults' intention to use medical apps during the COVID-19 pandemic in China, which, as can be seen from the following discussion, requires a combination of the UTAUT model and the TAM.

TAM postulates that (a) people's intention to use new technology is dependent upon their attitudes and (b) their attitudes towards new technology are influenced by technology's perceived usefulness and perceived ease of use (Davis, 1989). Users' attitudes towards certain technology (*e.g.* satisfaction) refers to the psychological state of users' emotional responses, such as favourable or unfavourable responses, when their previous expectations towards certain technology are confirmed or not (Davis, 1989). Behaviour intention refers to the belief that an individual will perform a certain behaviour in reality (Ajzen and Fishbein, 2005). Perceived usefulness refers to the extent to which users find a particular technology helpful in improving their work and life (Davis, 1989). Perceived ease of use refers to the extent to which users believe that adopting a particular technology is effortless (Davis, 1989). According to TAM, we proposed the following three hypotheses:

H1: Attitudes towards use are positively related to intention to use.
H2: Perceived usefulness is positively related to attitudes to using.
H3: Perceived ease of use is positively related to attitudes to using.

The variables shown in the original TAM model mainly focus on the features of the technology itself (Davis, 1989). Recent efforts have also been made to investigate variables on social (*e.g.* subjective norm; SN) and organisational (*e.g.* facilitating conditions; FC) (Agustina and Indriati, 2018) levels to explain user satisfaction with certain technology. SN refers to 'the extent to which an individual perceives that significant others believe he or she should use the new system' (Venkatesh *et al*., 2003: 450). According to the Expectation-confirmation Theory, people tend to form a positive attitude if significant others, such as family members (Cheng *et al*., 2008), friends (Lian, 2015), co-workers (Brown *et al*., 2015) and experts (Cheng, 2011), also have similar feelings (Agustina and Indriati, 2018; Ma *et al*., 2019).

FC refers to 'the degree to which an individual believes that an organisation and technical infrastructure exist to support the use of the system' (Venkatesh *et al*., 2003: 453). Facilitators include the resources (hardware, software and training knowledge) (Lian, 2015), technical assistance (Nistor *et al*., 2014) and compatibility with other technologies (Nistor *et al*., 2014). People with these facilitators tend to be satisfied with a certain product (Agustina and Indriati, 2018). Following this logic, we postulated the following hypotheses:

H4: The subjective norm is positively related to attitudes to using.
H5: Facilitating conditions are positively related to attitudes to using.

There are four antecedents of the UTAUT model: performance expectancy (*e.g.* perceived usefulness), effort expectancy (*e.g.* perceived ease of use), social influences (*e.g.* subjective norm) and facilitating conditions. During this epidemic, even the older people who, more often than not, suffer from chronic diseases are not allowed to leave home to see a doctor as usual. Thus, in this case, the older adults' intention to use online medical services is dependent on the app's usefulness, ease of use (de Veer *et al.*, 2015; Hoque and Sorwar, 2017) and how significant others (Alam *et al.*, 2020), such as doctors, peers, particularly those who suffer from similar diseases and family members (Or and Karsh, 2009), influence them, and whether they have better technological knowledge and skills, and devices that promote their use (Yuan *et al.*, 2015). Thus, based on the UTAUT model, the following hypotheses were proposed:

H6: Perceived usefulness is positively related to intention to use.
H7: Perceived ease of use is positively related to intention to use.
H8: The subjective norm is positively related to intention to use.
H9: Facilitating conditions are positively related to intention to use.

Based on the discussions above, we proposed the research framework shown in Figure 1.

Methodology

Sample

China closed off the city of Wuhan on 23 January 2020, to stop the spread of the deadly virus due to the impact of the COVID-19 pandemic. Other areas of China subsequently started the first-level response to address this public health emergency. Several measures, such as grid management, were implemented immediately to minimise contacts among people, and all outdoor activities were called off. People were called on to stay at home for at least 14 days.

Our data were collected during this period, from 26 January to the end of February 2020. We commissioned a local professional data survey company to help us collect the data. They first approached community workers, told them the research purpose and gave them online questionnaire, which could be accessed by scanning a QR code. In other words, the community was the intermediary institution, helping us to distribute research information to the older people aged 60 or above (Han *et al.*, 2020). It took participants approximately 30 minutes to finish the online survey. Those who completed the survey and successfully submitted it were rewarded with CNY20 (approximately US $3). The survey was completed by 1,318 participants and their data were used for further analysis. All respondents were informed in advance that the information would be confidential and used for research purposes only. They were also told that they could withdraw from the study at any time without giving a reason.

At the beginning of the questionnaire, we described the following scenario to them: an increasing number of health apps, such as Chunyu Yisheng (Dr Chun

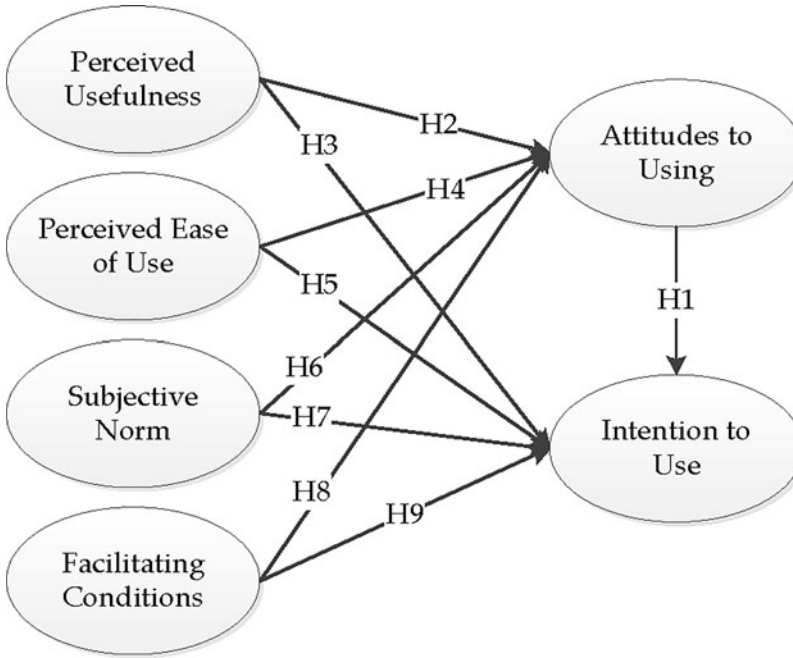

Figure 1. Research framework.
Note: H: hypothesis.

Yu), Xunyi Wenyao (seeking medical advice), Dingxiang Yisheng (Dr Clove), appear. There are thousands of certified doctors on these medical apps and they can provide one-to-one online consulting services to the public. At the same time, potential patients can also check others' consultation experiences and obtain relevant medical knowledge. All in all, people can consult professional doctors without leaving home. This is of great significance when all outdoor activities are cancelled. Thus, we seek information about the informants' willingness to turn to these medical apps for professional medical services under these circumstances.

Among the 1,318 participants, 71.5 per cent were men and 28.5 per cent were women; 73.4 per cent of the respondents were from urban China and 26.6 per cent came from rural China. The average age of our respondents is 63.98 years (range = 60–75; standard deviation = 3.243). It should be noted that the technical knowledge of our respondents may be better than the average level among older adults in China because of the electronic survey we employed. Although older people are important online consumers in China, only 20 per cent of them can surf the internet, and basic operations such as downloading and using applications are still their biggest obstacles (Tencent, 2018). It is one of our limitations.

Measures

All variables were measured with a seven-point Likert scale, from 1 = strongly disagree to 7 = strongly agree.

Perceived usefulness

Perceived usefulness was measured with five items from previous studies (Adams *et al*., 1992; Straub *et al*., 1997; Moon and Kim, 2001; van der Heijden, 2003). The sample item for the scale is 'I find it convenient to use medical apps'; reliability is 0.906.

Perceived ease of use

Perceived ease of use was measured with four items from the previous work (Adams *et al*., 1992; Straub *et al*., 1997; Moon and Kim, 2001; van der Heijden, 2003). The sample item for this construct is 'I think it easy to use medical apps'; Cronbach's α is 0.9.

The subjective norm

Five items from previous work (Davis, 1989; Moore and Benbasat, 1991; Venkatesh *et al*., 2003) were employed to measure the subjective norm. The sample item for this scale is 'Basically, people around me want me to use medical apps' services'; reliability is 0.914.

Facilitating conditions

Four items from previous studies (Ajzen, 1991; Compeau *et al*., 1999) were utilised to measure the facilitating conditions. The sample item is 'I have the necessary resources, such as mobile phones, to use medical apps'; reliability is 0.862.

Attitudes to using

Four items from previous studies (Adams *et al*., 1992; Straub *et al*., 1997; Moon and Kim, 2001; van der Heijden, 2003) were employed to measure this construct. The sample item for this scale is 'I like to use medical apps'; reliability is 0.913.

Intention to use

Four items from previous work (Adams *et al*., 1992; Straub *et al*., 1997; Moon and Kim, 2001; van der Heijden, 2003) were utilised to measure intention to use. The sample item for this dimension is 'I would like to recommend other older people to use medical apps'; Cronbach's α is 0.918.

Data analysis

Structural equation modelling (SEM) allows a detailed analysis of the complex interrelationships between observed and latent variables. Partial least squares SEM (PLS-SEM) is a particularly well-known method used to estimate these relations, which has been widely used in informational sciences (Hair *et al*., 2017*a*), psychology and business (Sarstedt *et al*., 2020), *etc*. Compared to covariance-based SEM (CB-SEM), in PLS-SEM, the variance-based technique relaxes some research assumptions. It enables researchers to estimate complex models with many observed variables, latent variables and structural paths without imposing distributional assumptions on the data (Hair *et al*., 2019*a*). More importantly, it emphasises the predictive function of the model, the basis for proposing managerial implications, rather than the explanatory function that is usually emphasised in

previous studies (Hair *et al.*, 2019*b*). When the analysis involves testing a theoretical framework from the predictive perspective, PLS-SEM is highly recommended (Hair *et al.*, 2019*a*). Based on the UTAUT and TAM theory, our research is very interested in the predictive power of the integrated model, that is, whether the older adults had the intention to employ medical apps during the epidemic. Therefore, we performed the PLS-SEM analysis with the SmartPLS (v.3.2.9) software (Ringle *et al.*, 2015).

Ethical concerns

Despite the absence of official ethical review institutions in social sciences in most universities in mainland China, we take research ethics very seriously in our research process. First, we used an anonymous online survey and deliberately avoided asking any questions that included identifiable information to protect our participants' privacy. Second, we had a consent letter at the beginning of our questionnaire that clearly stated the information about this research project, the researchers and their rights as research participants. In this letter, we specifically mentioned that they had the right to stop participating at any time and that there would be no any adverse consequences if they chose to do so. Finally, all the data collected are kept and used only by the researchers and for academic purposes.

Results

The two-step approach recommended by scholars was employed to perform the analysis (Anderson and Gerbing, 1988). First, the measurement model was estimated, which involved the examination of indicator loadings, internal consistency reliability, convergent validity and discriminant validity (Hair *et al.*, 2019*a*). After the measurement models met the criteria requirements, the structural model was evaluated (Hair *et al.*, 2017*b*), which included the assessment of the coefficient of determination (R^2), the blindfolding-based cross-validated redundancy (Q^2) and the path coefficients and significance test. The study also performed a bootstrapping mediation evaluation to understand the mediation effect of attitudes to using apps.

Measurement model

The standard for the item reliability was met if the factor loadings were above 0.708 (Hair *et al.*, 2019*a*). Composite reliability was used to assess internal consistency reliability, and values more than 0.95 were undesirable (Hair *et al.*, 2019*a*). The convergent validity was evaluated by the average variance extracted (AVE). The minimum acceptable value of AVE was 0.50, which meant that the construct could explain more than 50 per cent of the items' variance (Hair *et al.*, 2019*a*). Finally, the discriminant validity was assessed (Fornell and Larcker, 1981). According to Fornell and Larcker (1981), if the square root of AVE was more than the correlations of the constructs, the discriminant standards could be met.

In our data, the composite reliability was less than 0.95, and AVE was above 0.50 (*see* Table 1), indicating the standards for internal consistency reliability and

Table 1. Reliability and average variance extracted (AVE) of the measurement model

Construct	Indicators	Factor loading	Composite reliability	AVE
PU	PU1	0.907	0.941	0.842
	PU2	0.908	–	–
	PU3	0.937	–	–
PEU	PEU1	0.879	0.937	0.832
	PEU2	0.926	–	–
	PEU3	0.931	–	–
SN	SN1	0.914	0.946	0.853
	SN2	0.944	–	–
	SN3	0.912	–	–
FC	FC1	0.854	0.915	0.782
	FC2	0.920	–	–
	FC3	0.877	–	–
AU	AU1	0.911	0.945	0.852
	AU2	0.918	–	–
	AU3	0.939	–	–
IU	IU1	0.927	0.948	0.859
	IU2	0.899	–	–
	IU3	0.954	–	–

Notes: PU: perceived usefulness. PEU: perceived ease of use. SN: subjective norm. FC: facilitating conditions. AU: attitudes to using. IU: intention to use.

convergent validity could be met. The minimum square root of the AVE was 0.884, which was larger than the maximum correlation of 0.827 (*see* Table 2), indicating that the discriminant validity met the requirements.

Structural model

The structural model was evaluated by R^2, Q^2, path coefficients and a significance test. R^2 showed the percentage of explanatory power for the endogenous constructs, and it represented the predictive power of the model (*see* Figure 2). R^2 thresholds of 0.75, 0.50 and 0.25 were seen as substantial, moderate and weak (Hair *et al.*, 2011). In our data, the predictive power of the perceived usefulness, perceived ease of use, the subjective norm and the facilitating conditions of the attitudes towards using apps was substantial ($0.807 > 0.75$), and the predictive power of the intention to use apps was weak to moderate (0.492).

A Q^2-value larger than zero for a specific endogenous construct indicated the predictive accuracy of the structural model for that construct. According to Hair *et al.* (2019*a*), Q^2 larger than 0, 0.25 and 0.50 indicated the small, medium and large predictive relevance of the model. In our data, the Q^2 of attitudes towards

Table 2. Fornell–Larcker criterion for discriminant validity

	AU	FC	IU	PEU	PU	SN
AU	0.923					
FC	0.776	0.884				
IU	0.670	0.647	0.927			
PEU	0.821	0.733	0.575	0.912		
PU	0.827	0.693	0.607	0.736	0.918	
SN	0.618	0.596	0.431	0.653	0.542	0.923

Notes: Diagonals (bold) represent the square root of the average variance extracted while the other entries represent the correlations. PU: perceived usefulness. PEU: perceived ease of use. SN: subjective norm. FC: facilitating conditions. AU: attitudes to using. IU: intention to use.

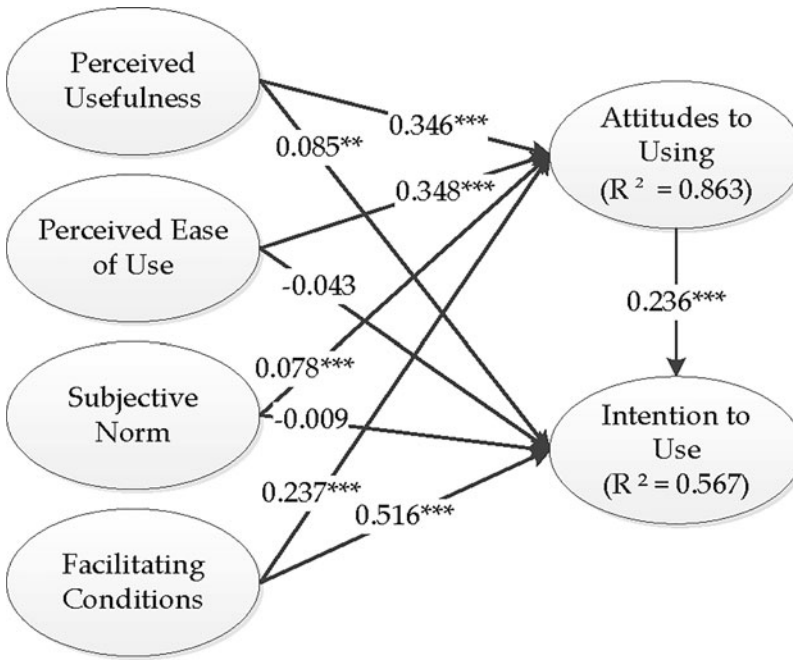

Figure 2. Path coefficients and R^2-values of the structural model.
Significance levels: ** $p < 0.01$, *** $p < 0.001$.

using apps was 0.683, indicating the large predictive power of the model. The Q^2 of intention to use apps was 0.416, indicating the medium to large predictive power of the model.

Path coefficients showed the significance and directions of the relations proposed in the model. Bootstrapping was employed to evaluate the path's significance (Hair *et al.*, 2011). Figure 2 and Table 3 summarise the results of the significance

Table 3. Summary of structural model results

Hypotheses		Path coefficients	*t*	Supported
H1	AU → IU	0.360***	6.794	Yes
H2	PU → AU	0.402***	15.390	Yes
H3	PEU → AU	0.323***	10.690	Yes
H4	SN → AU	0.053*	2.543	Yes
H5	FC → AU	0.229***	9.002	Yes
H6	PU → IU	0.124**	3.441	Yes
H7	PEU → IU	−0.025	0.518	No
H8	SN → IU	−0.033	0.929	No
H9	FC → IU	0.319***	7.631	Yes

Notes: Number of bootstrap samples = 10,000. PU: perceived usefulness. PEU: perceived ease of use. SN: subjective norm. FC: facilitating conditions. AU: attitudes to using. IU: intention to use.
Significance levels: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

test. Two hypotheses were not supported: H7 (PEU → IU) and H8 (SN → IU). H7 showed that perceived ease of use could not predict older people's intention to use apps ($\beta = -0.025$, $t = 0.518$), and H8 demonstrated that the subjective norm was not significantly related to the intention to use apps ($\beta = -0.033$, $t = 0.929$).

The rest of the hypotheses were supported. H1 showed that attitudes towards using apps positively and significantly predicted the intention to use apps ($\beta = 0.360$, $t = 6.794$), which meant that those satisfied with the medical apps intended to use them. H2 demonstrated that perceived usefulness was positively and significantly associated with attitudes towards using apps ($\beta = 0.402$, $t = 15.390$), showing that people would be satisfied with the medical apps if they thought they were useful. H3 showed that perceived ease of use was positively and significantly related to attitudes towards using apps ($\beta = 0.323$, $t = 10.690$), indicating that people would be pleased with medical apps if they thought apps were easy to use. The subjective norm had a positive and significant association with attitudes to using; thus, H4 was supported ($\beta = 0.053$, $t = 2.543$). It suggested that others easily influenced older people, and because of this, they tended to use medical apps if other people spoke highly of these apps.

H5 showed that facilitating conditions significantly impacted the attitudes to using apps in a positive manner ($\beta = 0.229$, $t = 9.002$). It showed that people would be pleased with medical apps if they had access to related devices, such as the internet and mobile phones. Perceived usefulness positively impacted the intention to use medical apps ($\beta = 0.124$, $t = 3.441$), supporting H6. It meant that people tended to ask for help with medical apps if they thought these apps were useful to them. H9 illustrated that facilitating conditions positively and significantly impacted intention to use medical apps ($\beta = 0.319$, $t = 7.631$). It showed that senior citizens were likely to use medical apps if they had related facilities, such as mobile phones.

Table 4. Mediation effect

Specific mediation effects	Original sample	Sample mean	Standard deviation	*t*	*p*
FC → AU → IU	0.083***	0.083	0.015	5.333	0.000
PEU → AU → IU	0.116***	0.117	0.020	5.859	0.000
PU → AU → IU	0.145***	0.145	0.023	6.205	0.000
SN → AU → IU	0.019*	0.019	0.008	2.317	0.020

Notes: Number of bootstrap samples = 10,000. PU: perceived usefulness. PEU: perceived ease of use. SN: subjective norm. FC: facilitating conditions. AU: attitudes to using. IU: intention to use.
Significance levels: * $p < 0.05$, *** $p < 0.001$.

Mediation analysis

A bootstrapped 95 per cent confidence interval was generated to examine the mediation effects. The literature (MacKinnon *et al.*, 2004) indicates that indirect effects can be confirmed if zero is not included in the confidence interval. Table 4 shows the results, including the original sample, the sample mean, the standard deviation, and the *t*-statistics and *p*-values. The findings illustrated that the attitudes towards using medical apps mediated all the paths, which identified satisfaction as the important mechanism, linking perceived usefulness, perceived ease of use, subjective norm and facilitating conditions with people's intention to use medical apps. The current study's findings suggest that senior citizens' intention to use medical apps is conditioned by their attitudes even if the attributes of apps are excellent (*e.g.* useful and easy to use), and the surrounding environments (*e.g.* internet and other people's influence) are well prepared. In other words, senior citizens' 'attitudes' to medical technologies is of great importance in the apps utilisation process.

Conclusion and discussion

We constructed a research model based on TAM and UTAUT models and used SEM to examine older people's intention to use medical apps for information and services during the COVID-19 pandemic in China. In line with previous studies, our empirical findings provide insight into the UTAUT constructs, such as how the perceived usefulness and facilitating conditions influence the adoption of medical apps (Hoque and Sorwar, 2017; Byambasuren *et al.*, 2020; Lan *et al.*, 2020). Also consistent with previous work is the finding that attitudes towards medical apps are also a significant antecedent of behaviour intention (Askari *et al.*, 2020; Byambasuren *et al.*, 2020).

However, the remaining two factors in the original UTAUT model, perceived ease of use and subjective norm, did not predict users' intentions. Past research has shown that when a system is mandatory, perceived ease of use is not significantly related to intention to use (Venkatesh *et al.*, 2003; Holtz and Krein, 2011), which also explains our case. Our data were collected from 26 January to the end of February 2020, when China implemented the first-level response (*i.e.* grid management and all outdoor activities cancelled) to prevent the spread of the

deadly virus, and almost all the resources were amassed and sent to Wuhan to ensure their usage (China Development, 2020). Hospital appointments for chronic diseases were not guaranteed in this context; thus, increasingly, the use of medical apps has become mandatory for older adults. Accordingly, perceived ease of use is not significantly related to their intention to use medical apps.

Therefore, the subjective norm measure in our research may not be as important as once assumed (Venkatesh *et al.*, 2003). Although comments from significant others seem like an important factor in determining what people use, the UTAUT model uses subjective norms as an antecedent (*i.e.* if people suppose using a particular technology is expected by those who consider it significant, they would use it too). However, the lack of significance seen in our research could indicate descriptive norms, where their app usage might depend on what an individual perceives to be the actual norm (Cialdini *et al.*, 1991). In other words, the older people in our sample might not be easily influenced by others and have their own opinions on whether to use medical apps.

Besides factors that are directly related to the older adults' intention to use medical apps, we also find that the older people's attitude to using these apps can serve as an important channel, through which the measures of perceived usefulness, perceived ease of use, subjective norm and facilitating conditions can have a significant impact on their intention to use apps. Older people lag behind in technology use compared to the rest of the population (Huxhold *et al.*, 2020), particularly in the context of today's rapidly changing technology (Vicente, 2021). To our relief, older people worldwide have already realised the importance of this change, and have gradually begun to use electronic products (Li *et al.*, 2017; Mohlman and Basch, 2021). This positive change in the attitude of older adults towards using technology can inspire future marketing campaigns. Providers of medical apps need to extend their focus from the usefulness and ease of use of their products to building a positive image of their products or their companies among their potential clients. They could also receive regular feedback from older people about their products to improve updated versions.

We believe that the factors and mechanism identified in our research are crucial to implementing eHealth services in the Fourth Industrial Revolution. Big data and cloud storage could be used to collect and address common problems of older people to enable those with similar diseases to search for and check their symptoms (Yang, 2019). We also believe it is very likely that using medical apps to access professional help will become the norm in a post-pandemic era. When we wrote this article, the COVID-19 variants were only Alpha and Beta. Since then, mutations including Gamma, Delta and Lambda have emerged, and we are now experiencing Omicron, whose overall global risk is rated as 'very high' by the World Health Organization. Many countries (*e.g.* Japan) have even closed their borders. Whether we like it or not, Omicron will not be the last variant, and China's case has lessons for other countries.

However, our findings are not without limitations. The sample component is one issue. We delivered our questionnaires through the internet, which means that older people who do not use the internet were excluded from the sampling process. This digital inequality among different groups further highlights the importance of paying special attention to the older adults in the Fourth Industrial

Revolution. Future research should continue our efforts in two ways. Attention should be paid to those who choose not to use the internet by investigating their main reasons for rejecting it (*e.g.* Weaver *et al.*, 2010), and possible strategies to encourage them to use the internet and medical apps should be developed. Researchers also need to focus on older people who cannot use the internet for socio-economic reasons and take these people into account in providing health care in the Fourth Industrial Revolution.

Our methodology also contains limitations. First, we employed a cross-sectional research design, thus, the variable relations cannot be interpreted as causality. Second, we have only included those who completed the survey in our total number of respondents (1,318); in other words, those who rejected the survey invitation and those who did not finish the survey were not included. Therefore, the return rate of this article cannot be calculated. Last but not least, future studies should pay attention to the courtesy bias, where respondents answer the questions in a way they expect researchers to potentially want them to, especially when they will be compensated for their participation. Although we used reversed code items and participants were not told explicitly about how much money they could obtain from this survey, the courtesy bias still cannot be fully addressed.

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