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Continued use of mobile apps for health promotion

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Dissertation presented as partial requirement for obtaining the Master's degree in Information Management

NOVA Information Management School
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CONTINUED USE OF MOBILE APPS FOR HEALTH PROMOTION

by

Beatriz Martins Miranda

Dissertation presented as partial requirement for obtaining the Master's degree in Information Management, with a specialization in Knowledge Management and Business Intelligence

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ABSTRACT

Mobile health (mhealth) applications (apps) promotion has been increasingly used year after year. They have recently played an important role in preventing an unhealthy society. Mhealth apps have been developed in different areas of health, increasingly satisfying user goals. The aim of this study was to explore and understand important factors that contribute to the use behavior and the intention to continuation use mhealth apps, in combination with the self-determination theory, and produce well-being and consciousness in health. This study extends the findings continue usage, along with the intrinsic motivation of each consumer that drives well-being. We obtained 306 valid responses through an online questionnaire created in qualtrics from participants that use mhealth apps. We applied the partial least squares structural equation modelling (PLS-SEM) technique to test the research model. Our study contributes to the continuance theory of use mhealth apps. The model has found that the intrinsic motivation, satisfaction, perceived usefulness, and use behavior have a significant effect on continuance intention. Our study demonstrates a significant role in a society that uses mhealth apps and that their use reflects a well-being with moderation effect of health consciousness.

KEYWORDS

Continuance intention; Health consciousness; Mhealth apps; Self-determination theory; Well-being

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LIST OF ABBERVIATIONS AND ACRONYMS

Apps: Applications

AVE: Average variance extracted

CET: Cognitive evaluation theory

CR: Composite reliability

ECM: Expectation-confirmation model

ECT: Expectation-confirmation theory

HTMT: Heterotrait-monotrait

IS: Information systems

mhealth: Mobile health

PLS: Partial least squares

PAM: Post-acceptance model

SDT: Self-determination theory

SEM: Structural equation model

UTAUT: Unified theory of acceptance and use of technology

UTAUT2: Extended unified theory of acceptance and use of technology

VIF: Variance inflation factor

1. INTRODUCTION

Since the creation of the first application, the use of mobile devices has increased due to the human need to use different applications for different activities (Hur et al., 2017) and the importance of having better health is no exception (Alam et al., 2020). The increase in average life expectancy (Cho, 2016), the healthy lifestyle (Stiglbauer et al., 2019), the well-being (Gál et al., 2021) have resulted in increased interest in mobile applications that can manage health in real time (Roberts et al., 2021). Mobile health applications or mhealth apps *"are aimed to help people in the management of their lifestyle or a particular disease"* (Nunes et al., 2019). In addition, the pandemic context of COVID-19 that started in 2020, brought the confinement and growth in the use of mhealth apps, with an increase in March of 40% in downloads (Yan et al., 2021).

Currently, the mhealth apps available for both healthcare professionals and simple users are related to fitness, lifestyle, mindfulness, nutrition, etc. or specified in medical health (health providers, medical education, disease management or self-diagnosis) (Peng et al., 2016). Mobile devices offer significant advantages to their users, in terms of portability and the ability to install mobile apps. Consumers who have already adopted apps for their health, can understand the benefits of its continued use in a proactive way by using a variety of apps (Cho, 2016).

Few research has been carried out regarding the need to further explore consumer decisions to continue using mhealth apps and don't focus a lot on the post-adoption behaviors. The main focus of this study is based on solving this gap (Cho, 2016). Many studies focus on understanding the main factors that affect the actual usage behavior (Alam et al., 2020; Salgado et al., 2020), the perception factors that contribute to the adoption of mhealth apps for well-being (Aboelmaged et al., 2021) and recent studies on well-being in the use of these technologies in the pandemic context (Alam et al., 2021), psychological facts (health consciousness) to predict intention to use mhealth apps (Cho et al., 2014; Meng et al., 2019), and features of mhealth apps agreeing to the self-determination theory (SDT) for behavior change (Villalobos-Zúñiga & Cherubini, 2020). Also, we develop a research model to explain the post-adoption of continuance intention and users' use of mhealth apps, understanding the intrinsic motivation using SDT, consciousness, and well-being. Studying continuance intention for mhealth apps it's essential because changing sedentary lifestyle and unhealthy habits it's challenging, and it's also difficult to keep a consumer active in the use of the applications and with health consciousness (Yan et al., 2021; Peng et al., 2016).

Despite being a transformation forced by the pandemic, the truth is that today we use and enjoy apps like we never imagined before. With this, we know that their continued use depends on many factors, such as, in spite of the need to explore why people continue using mhealth apps, few researches have been aimed on the topic (Cho, 2016). This study, in addition to mobile applications, also studied wearable technologies, because they need an app to store data for consumers can use 100% of the technology's functionality (Nascimento et al., 2018). In addition to the studies that have been carried out on specific health (Engelsma et al., 2021) or on specifics apps (Baxter et al., 2020), this paper is aimed at the whole concept of mobile apps for health, that can be downloaded from app stores.

The contributions of this research are four. First, the main focus of this research will be on the post-acceptance of mobile apps for health promotion, based on Bhattacherjee model, capable of explaining the outcomes of confirmation and satisfaction on users' intention of continuity in using a new technology, as a mediator of perceived usefulness (Bhattacherjee, 2001). Second, completing the model with the autonomy, relatedness competence, and well-being, makes the research provide information about the real motivations that exists in the relation between individuals and activities (Ryan & Deci, 2000a) and the factors that drive the actual use to consumer intention. Third, well-being was also given special focus because we were able to address the question of how use and intention to use impact the overall sense of well-being (El Hedhli et al., 2013). In addition, this research shows that health consciousness consumers moderate the effect on both use and intention on well-being. Fourth, the use of mhealth apps has increased and few studies are sufficient to explain what intrinsic motivation influences the continued use of the technology and how positively affects the well-being and how health consciousness has a real impact to sustain the mhealth app.

The paper has the following structure. In the next section, extending literature review, we explain the mhealth apps, continuance theory, the post-acceptance model (PAM), the unified theory of acceptance and use of technology (UTAUT), the self-determination theory, well-being, and health consciousness. Following section, the research model is conceptualized, and tested hypothesis are described. The results of this research are described after research model section. In the last parts we review our work with theoretical and practical implications along with limitations and the conclusions.

2. LITERATURE REVIEW

2.1. MHEALT APPS

In the last decade the phenomenal growth of smartphones is notorious, as well as downloading apps (Xu et al., 2015). With the rapid development and attractiveness of apps and the technologies that support them, mhealth apps has become a perfect match for society in innumerable contexts (Aboelmaged et al., 2021). World Health Organization defines mhealth as *"medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants, and other wireless devices"* (Ryu, 2012). There is potential for mhealth apps to transform healthcare service delivery (WHO Global Observatory for eHealth, 2011), inclusive these apps have several functions to monitor health-related behaviors or disease prevention for the general public, some or all features are free, and apps are easily accessible (Nunes et al., 2019). These apps provide many alternatives of health services from crisis intervention to prevention of healthcare services, healthcare promotion and self-management (Alam et al., 2020). Although mhealth apps could store multiple types of users' data (Lim & Noh, 2017). In the 1st quarter of 2021, 53.054 mhealth apps were available in the google play store representing a 6.51% increase over the 4th quarter of 2020 with 49.809 mhealth apps (Statista Research Department, 2021). Apps for health can promote: physical activity (Huang & Ren, 2020; Barkley et al., 2020; Lim & Noh, 2017), feeding control (Akdur et al., 2020; Franco et al., 2016; Samoggia & Riedel, 2020), sleep control (accompanied if the user has wearable devices) (Choi et al., 2018), women's health (femtech market) (Nayeri, 2021; Blödt et al., 2018; Ford et al., 2020; Hussain-Shamsy et al., 2020), smoking cessation (Luna-Perejon et al., 2019; Abroms et al., 2013; Chevalking et al., 2018), mindfulness (Gál et al., 2021; Beer et al., 2020), etc. The principal objective of these apps is to increase the user's health, as a result of user's active self-management and involvement in healthcare (Nunes et al., 2019). In addition to the main functionality of each app, mhealth apps include some features that create motivation, awareness, and healthy behavior on the part of the user in intending to continue using an app, for example: reminders, goal setting, motivational messages, recording exercise data, feedback, history, self-monitoring, rewards, performance sharing and challenge peer (Roberts et al., 2021; Peng et al., 2016; Aboelmaged et al., 2021; Villalobos-Zúñiga & Cherubini, 2020; Lim & Noh, 2017; Alessa et al., 2018). This study will not focus on a specific mhealth app or type of health, it is on all health applications that can promote a continued use and result of a well-being.

2.2. THEORETICAL FOUNDATIONS

The number of mhealth apps has been increasingly and with this rapid development we understand the importance of mhealth apps and their use. In this study we focus on continuance intention of mhealth apps, applying PAM combined with use behavior endogenous variable from UTAUT2, and the motivation to continue to use from SDT that results from a well-being and health consciousness to explain users' motivation and behaviors to the continuance use of mhealth apps. Although studies focus on continuance theory (Cho, 2016), adoption (Duarte & Pinho, 2019) and actual use (Salgado et al., 2020) related with mhealth. Nonetheless, smartphone apps, smartwatches, e-learning and mhealth devices share some characteristics with mhealth apps and some features can be used as a guide. Table 2.1 summarizes the most relevant studies.

To study the post-acceptance behavior, Bhattacherjee explained the continuous use of information systems (IS) by proposing a model: the post-acceptance model (Bhattacherjee, 2001). PAM uses expectation-confirmation theory (ECT) concept to focus on pre-acceptance confirmation and satisfaction variables and use the post-experience expectations interpreted by perceived usefulness construct. Recently, the models PAM and ECT has been adopted by researchers (Cho, 2016; Wang et al., 2021). Cho (2016) concluded that perceived usefulness, confirmation, and satisfaction contribute to the post-adoption behaviors of people using mhealth apps. Nascimento et al. (2018) extend the expectation-confirmation model (ECM) with the others constructs and determinate satisfaction and perceived usefulness have a significant effect on continuance intention. On the other hand, other studies followed more the human motivation. The adoption of new technology can be determined by intrinsic motivation (Ryan & Deci, 2000a). Intrinsic motivation is an example of human nature tendencies of active integrative assumed by SDT, here is an empirically based theory of human motivation and wellness (Ryan & Deci, 2020). Specifically, SDT argues that, for healthy growth, users need support for basic psychological needs (Ryan & Deci, 2020). Autonomy, competence, and relatedness are the three needs seen as mostly fundamental. However, some studies linked the continuance theory with intrinsic motivation (Nikou & Economides, 2017; Rezvani et al., 2017; Rahi & Ghani, 2019). Wang et al. (2021) innovatively used ECM and SDT to explain psychological aspects of gamification elements that promote the continuance intention of mhealth apps usage. Sørebø et al. (2009) concluded that the impact of perceived competence was greater than perceived autonomy on intrinsic motivation in e-learning usage. Therefore, in post-adoption context, as the experience increases, the expectation of users also increases and will be based on the actual user experience (Rahi & Ghani, 2019). Venkatesh et al. (2003) developed UTAUT which they later extended to UTAUT2 (Venkatesh et al., 2012) in order to explain users' intentions to use an IS and the subsequent use behavior of the technology. Recently, to assess actual use behavior of mhealth, UTAUT is considered the most valid technology acceptance model (Pan & Gao, 2021). Several studies explain adoption of mhealth with the configurations of UTAUT2 (Duarte & Pinho, 2019). Alam et al. (2020) analysed the factors that tend to alter the behavioral intent and actual usage behavior of mhealth app adoption in Bangladesh among the younger generation that are most frequently exposed to technology. Hoque & Sorwar (2017) based on the UTAUT identified the factors influencing the intention of elderly patients to use mhealth in Bangladesh and found that the intention was influenced by performance expectancy, effort expectancy and social influence. Salgado et al. (2020) understood the individual mhealth acceptance drivers and reveals an intention to use, use behavior, and behavioral intention to recommend mhealth based on UTAUT2. In addition, some articles concluded the importance of health consciousness and well-being of health is inherently related to with the different mhealth apps available on the market, but beyond that it perpetuates preventive health behavior (Gál et al., 2021; Aboelmaged et al., 2021; Jayanti & Burns, 1998; Li et al., 2020) or related with consumer well-being research (El Hedhli et al., 2013).

Authors	Theory(ies)	Variables	Method	Data
Cho (2016)	Post-Adoption Model (PAM); Technology Acceptance Model (TAM)	Confirmation; Perceived usefulness; Perceived ease of use; Satisfaction; Continuance intention to use	Structural equation modeling	Online survey of 343 Korean adults, that currently using mhealth apps
Nascimento et al. (2018)	Expectation-confirmation model (ECM)	Confirmation; Perceived usefulness; Satisfaction; Continuance intention; Habit; Perceived usability; Perceived enjoyment	Structural equation modeling	Online survey of 574 American respondents, that using smartwatches
Wang et al. (2021)	ECM; SDT	Confirmation; Perceived usefulness; Satisfaction; Continuance intention; Intrinsic motivation for using the mhealth; competence; autonomy; relatedness	Structural equation modeling	Online survey of 307 from China respondents
Sørebø et al. (2009)	ECM; SDT	Perceived competence; Perceived autonomy; Perceived relatedness Confirmation; Perceived usefulness; Satisfaction; Continuance intention; Intrinsic motivation	Structural equation modeling	E-mail questionnaires distributed to 430 teachers of 12 university colleges
Alam et al. (2021)	Unified Theory of Acceptance 2 (UTAUT2)	Performance Expectancy; Effort Expectancy; Social Influence; Hedonic Motivation; Price Value; Facilitating Condition; Habit; Health Consciousness; Behavioral Intention; Self-Quarantine; Actual Usage Behavior; Mental Wellbeing	Structural equation modeling; Artificial Neural Network	Online survey of 434 that using mhealth at least once during the COVID-19
Duarte & Pinho (2019)	UTAUT2	Adoption of mhealth; Performance expectancy; Effort expectancy; Social Influence; Facilitating Conditions; Hedonic Motivation; Price Value; Habit	Structural equation modeling; Qualitative Comparative Analysis	Survey of 120 respondents using mhealth devices and apps
Aboelmaged et al. (2021)	Based on previous studies about technology readiness model and Unified Theory of Acceptance and Use of Technology (UTAUT)	Subjective wellbeing; Hedonic Value; Utilitarian Value; Innovativeness; Optimism; Discomfort; Insecurity	Structural equation modeling	Survey from 731 users of mhealth applications
Li et al. (2020)	Based on previous studies about attachment theory, basic psychological needs and well-being from patients'	Autonomy need satisfaction; Relatedness need satisfaction; Competence need	Structural equation modeling	113 in patients at the 8 hospitals in Shanghai, China used Recovery Helper app

	use of mhealth apps	satisfaction; IT-Enabled Self-Esteem; Physical Symptoms; Patients' emotional bonding with mhealth apps		
El Hedhli et al. (2013)	Based on previous studies about consumer well-being	Functional; Convenience; Safety; Leisure; Atmospherics; self-identification; Well-being; Mall loyalty; Positive WOM	Structural equation modeling	A shopper survey from 420 respondents of first mall and 300 respondents of second mall

Table 2.1 - Studies that support the research

3. RESEARCH MODEL

This research model combines several topics related to psychology, technology, and well-being. It explains what kind of motivation drives the use and continuance intention to use mhealth apps for precise well-being, and how health consciousness can be related to the use of mhealth apps. This model includes the post-adoption environment of mhealth apps where users decide on continuous (discontinued) use. Based on literature, we study about SDT, PAM, health, and wellness. Figure 3.1 presents the research model for health promotion. Each item and the research hypothesis are described below.

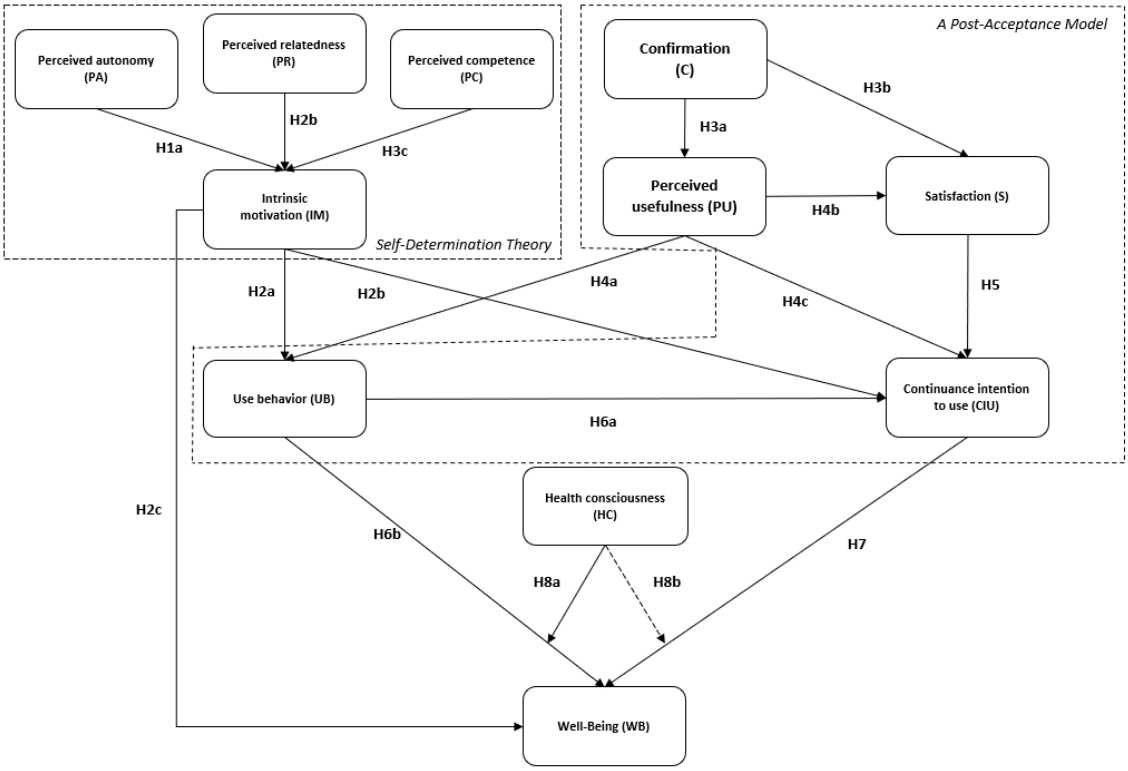

Figure 3.1 - Research model

3.1. PERCEIVED AUTONOMY

Perceived autonomy mentions to the intention to initiate and self-regulate one's own behavior (Rezvani et al., 2017). SDT describe perceived autonomy with an activity that increases extrinsic and intrinsic motivation (Ryan & Deci, 2000a; Sørebø et al., 2009; Jeno et al., 2019). A several mhealth features are associated to autonomy of user while enjoying the application, for example reminders, goal setting, motivational messages, and pre-commitment (Villalobos-Zúñiga & Cherubini, 2020; Ryan & Deci, 2000a). A few studies validate the relationship of perceived autonomy that trigger intrinsic motivation (Sørebø et al., 2009; Jeno et al., 2019; Wang et al., 2021). We hypothesize that:

H1: Perceived autonomy (PA) will positively influence the intrinsic motivation (IM)

3.2. PERCEIVED RELATEDNESS

Perceived relatedness refers to the interaction, stay connected with others and stay involved in social environments (Li et al., 2020; Ryan, 1995). SDT assume that relatedness is also an important role (Ryan & Deci, 2000a). Relatedness, as perceived autonomy and competence in social context, are the basis for one maintaining intrinsic motivation (Ryan & Deci, 2000b). According to Villalobos-Zúñiga & Cherubini (2020) mhealth apps have several features associated with relatedness: performance sharing, peers' comparison, challenge peer and messaging. A few studies validate the relationship (Sørebø et al., 2009; Wang et al., 2021). We hypothesize that:

H2: Perceived relatedness (PR) will positively influence the intrinsic motivation (IM)

3.3. PERCEIVED COMPETENCE

Perceived competence implies that users feel effective and capable (Rezvani et al., 2017). In carrying out an activity, competence stands out for the interest of being effective and sufficient (Nikou & Economides, 2017). According to the cognitive evaluation theory (CET) if feelings of competence are not followed by a sense of autonomy, they will not increase intrinsic motivation (Ryan & Deci, 2000b). CET affirms that feedback, rewards, communications conduce feelings of competence through action that can improve intrinsic motivation (Ryan & Deci, 2000b). According to Villalobos-Zúñiga & Cherubini (2020) mhealth apps have several features associated with competence: activity feedback, history, self-monitoring, and rewards. Perceived competence explained that positive performance feedback improved intrinsic motivation and that negative feedback diminished it where perceived competence mediated these outcomes (Ryan & Deci, 2000a; Ryan & Deci, 2000b). A few studies validate the relationship (Sørebø et al., 2009; Jeno et al., 2019; Markland, 1999). We hypothesize that:

H3: Perceived competence (PC) will positively influence the intrinsic motivation (IM)

3.4. INTRINSIC MOTIVATION

The positive potential of human nature is reflected by intrinsic motivation, as well as the inherent tendency to look for novelties and challenges to explore and learn (Ryan & Deci, 2000a). When a person is moved to act for fun or challenge, it is intrinsically motivated, as opposed to acting by external cues, pressures, or rewards (Ryan & Deci, 2000b). In UTAUT2 there is empirical evidence from motivation theory (Venkatesh et al., 2012) and intrinsic motivation can be a key factor in the decision to use a technology (Lee et al., 2005). Intrinsic motivation leads to users' well-being (Li et al., 2020; Deci & Ryan, 2000). A few studies validate the relationship of intrinsic motivation and continuance intention to use (Sørebø et al., 2009; Wang et al., 2021). We hypothesize that:

H4a: Intrinsic motivation (IM) will positively influence the use behavior (UB)
H4b: Intrinsic motivation (IM) will positively influence the continuance intention to use (CIU)
H4c: Intrinsic motivation (IM) will positively influence the well-being (WB)

3.5. CONFIRMATION

The PAM is based on the idea that users of the technology, after the first acceptance and use of it, can structure an opinion to which your pre-acceptance expectations are confirmed and the benefits/usefulness of using IS (Sørebø & Eikebrokk, 2008). Therefore, perceived usefulness is determined by the concept of confirmation (Park, 2020). According to research, confirmation is positively correlated to satisfaction with the use of technology as it requires achieving expected benefits of use IS (Bhattacherjee, 2001). Confirmation is identified as the perception of the perceived usefulness of each app for health between the user's satisfaction with their needs. In line with Bhattacherjee (2001), numerous studies validate the relationship (Cho, 2016; Nascimento et al., 2018; Wang et al., 2021). We hypothesize that:

H5a: Confirmation (C) will positively influence the perceived usefulness (PU)
H5b: Confirmation (C) will positively influence the satisfaction (S)

3.6. PERCEIVED USEFULNESS

According to Bhattacherjee (2001), the perceived usefulness influences the acceptance and decision to continue with the technology. In PAM, usefulness is related with the continued intention to use, because the human tendency to subconsciously seek rewards is independent of the timing of such behaviors (Bhattacherjee, 2001). It is expected that the most prominent post-consumption influencing users' satisfaction is perceived usefulness (Bhattacherjee, 2001). The more benefits users receive for using mhealth apps, the greater satisfaction will be generated, which allows an increase intention to continue using them (Nascimento et al., 2018). Although, perceived usefulness can also determine the user behavior and system (Davis, 1989). There are more studies about these positive relationships (Cho, 2016; Nascimento et al., 2018; Wang et al., 2021). We hypothesize that:

H6a: Perceived usefulness (PU) will positively influence the use behavior (UB)
H6b: Perceived usefulness (PU) will positively influence the satisfaction (S)
H6c: Perceived usefulness (PU) will positively influence the continuance intention to use (CIU)

3.7. SATISFACTION

After the use of a technology, the users' will evaluate it in order to perceive their satisfaction (Bhattacherjee, 2001). This satisfaction can be positive, indifferent, or negative (Li & Fang, 2019). According to the Bhattacherjee (2001) the post-acceptance model has a positive relationship between satisfaction and continuance intention to use a specific technology. It is estimated that after post-adoption and user satisfaction, they will continue to be a user of the health apps. There are studies that validate this relationship (Cho, 2016; Nascimento et al., 2018; Wang et al., 2021). We hypothesize that:

H7: Satisfaction (S) will positively influence the continuance intention to use (CIU)

3.8. USE BEHAVIOR

Behavior is an action whose prediction is useful in the model (Bozan et al., 2015). This dependent variable from UTAUT2 model suffered an update to the context of technologies aimed at consumer (Venkatesh et al., 2012). After mhealth apps are accepted, users start using them for real. The assessment of the benefits and impacts of usage occurs at this stage, where the likelihood of continuing to use mhealth apps will increase. There is a study, in another context, that validates the relationship. Oliveira et al. (2021) show that user behavior have a positive relationship with continuance intention to use in technology. In addition, recurrent and continuous use will allow users to benefit from a better mental and physical state, enhancing their well-being. We hypothesize that:

H8a: Use behavior (UB) will positively influence the continuance intention to use (CIU)
H8b: Use behavior (UB) will positively influence the well-being (WB)

3.9. CONTINUANCE INTENTION TO USE

Continuance intention to use was defined by Bhattacherjee as an intention to continue using the IS (Bhattacherjee, 2001). The choice to continue use mhealth apps can be the ideal decision, in which the application is performing well, and users show dedication to the goals because the app offers these opportunities to users (Vaghefi & Tulu, 2019). For example, Lin & Windasari (2018) explore the continued (vs. discontinued) use of wearable technologies and users' improvement in well-being is the end result of continuance usage, and they claim that technological efficiency enables users to well-being. Under these circumstances, we foresee the users to continue committed with the mhealth apps for larger periods, which eventually helps them to reach their goals. We hypothesize that:

H9: Continuance intention to use (CIU) will positively influence the well-being (WB)

3.10. HEALTH CONSCIOUSNESS

Health consciousness refers to the level of awareness or concerns in relation to a person's daily activities (Jayanti & Burns, 1998). It is noteworthy that users have their interests and are aware of their health conditions and well-being (Cho et al., 2014). It's possible to realize that a user that has a higher health consciousness, with a lower use behavior, will have greater well-being than a user with lower health consciousness and a lower use behavior. To explain it more clearly, when a user is not using a mhealth app very often but he or she have a higher health consciousness, the benefits of that usage will increase the well-being of the user.

H10a: Health consciousness (HC) moderates the effect of use behavior (UB) on well-being (WB)

4. METHODS

4.1. MEASUREMENT

With the objective of testing the research model and based on the literature, all measures were adapted: perceived autonomy (PA), perceived relatedness (PR), perceived competence (PC), intrinsic motivation (IM) adapted from Sørebø et al. (2009), Villalobos-Zúñiga & Cherubini (2020) and Deci & Ryan (2008); confirmation (C) and perceived usefulness (PU) from Bhattacherjee (2001); satisfaction (S) from Xu et al. (2015); use behavior (UB) from Alam et al. (2020) and Venkatesh et al. (2012); continuance intention to use (CIU) from Rezvani et al. (2017) and Bhattacherjee (2001); well-being (WB) from El Hedhli et al. (2013); health consciousness (HC) from Jayanti & Burns (1998). In appendix A we can find the items for all constructs.

The questionnaire was developed in Portuguese on qualtrics platform. All items were evaluated on a seven-point quantitative scale, ranging from “totally disagree” (1) to “totally agree” (7).

4.2. DATA

Firstly, was conducted a pilot survey with 30 responses to receive feedback. This questionnaire is only intended for mhealth apps users and was distributed to respondents, who knew the Portuguese language, in April 2021, for a total of 3 weeks. A total of 601 responses were collected. 205 participants did not complete the questionnaire until the end, so they do not count towards the final sample. After data cleaning it was retained a sample of 306 participants.

As represented in Table 4.1, concerning demographic data, 99% of the respondents are Portuguese here 8% are respondents under the age of 20; 69% of respondents range from 20 to 30 years; 23% have an age higher than 40 years, which makes up a young dataset regarding the use of apps for health promotion. There is a higher percentage (60%) of males responding to the questionnaire. Most of the respondents have an associate degree with 43% and high school with 29%. Age and gender were used as control variables in research model. In relation to use mhealth apps, it is possible to see that is still recent, where 41% have only used it for less than a 1 year and 7% have used it for more than 5 years (starting in 2016 and continuing to use this type of apps). According to the results of the questionnaire the fitness apps are the most used app with 57%. The second type of applications most used by respondents is feeding with 25% and 12% respondents use mindfulness type apps.

Sample characteristics (n=306)	Descriptive statistics
Age	
<20	8%
20-30	69%
>40	23%
Gender	
Female	40%
Male	60%
School level	
Elementary	2%
High school	29%
Associate degree	43%
Bachelor or master's degree	25%
Experience in mhealth apps	
<1 year	41%
1 - 2 years	34%
3 - 5 years	18%
> 5 years	7%
mhealth apps	
Fitness	57%
Feeding	25%
Mindfulness	12%
Others	5%
Country	
Portugal	99%
Others (Spain and Mozambique)	1%

Table 4.1 - Descriptive statistics of the sample

5. DATA ANALYSIS

To estimate the research model, we used the partial least squares (PLS) technique. We tested the 17 hypotheses of model using the structural equation modeling (SEM). SEM is a statistical method for verify the hypothetical theory using a statistical data and qualitative fundamental assumptions. For these research model, it was used Smart PLS software, version 3.3.3 (Ringle et al., 2015).

5.1. MEASUREMENT MODEL

A few measures were analysed to calculate the reflective measurement model. The estimation of model involves the indicator reliability; internal consistency (composite reliability); construct validity (loading and cross-loading); the average variance extracted (AVE); to verify discriminant validity we used the Fornell-Larcker criterion, the cross-loadings, and the Heterotrait-Monotrait Ratio (HTMT) (Hair Jr et al., 2014; Sarstedt et al., 2021).

We analyzed the indicator reliability based on the criterion that loadings must be greater than 0.7 and less than 0.4 must be excluded (Sarstedt et al., 2021). As shown in Table 10.2, the loadings are greater than 0.7 apart from S4, UB3 and WB1. These items were eliminated as a result of a low loading. Overall, a good indicator reliability is presented. Measure composite reliability (CR) indicates the reliability based on the interrelationship of the observed items variables (Hair Jr et al., 2014; Sarstedt et al., 2021). In Table 5.1, it is possible to confirm, on all constructs, a CR higher than 0.7 (Hair Jr et al., 2014; Sarstedt et al., 2021). AVE was used as the criterion to test convergent validity. This measure is supposed to be higher than 0.5 because the latent variable describes more than half of the variance of its indicators (Sarstedt et al., 2021; Fornell & Larcker, 1981). As shown in Table 5.1, the diagonal elements are the square-root of AVE and all constructs have to higher than 0.5, to meet this criterion. Table 5.1 shows discriminant validity with the Fornell-Larcker criterion, where the diagonal values correspond to the square root of AVE must be greater than the correlation with other constructs (Hair Jr et al., 2014; Sarstedt et al., 2021; Fornell & Larcker, 1981). According with the second criterion in table 10.2 from appendix B, requires that all loadings should be higher than the cross-loadings (Hair Jr et al., 2014). Third criterion in table 10.3 represents the HTMT where values should be below 0.9 (Henseler et al., 2015). These three measures confirm a discriminant validity. These constructs can be used to test the conceptual model.

	Mean	STD	CR	PA	PR	PC	IM	C	PU	S	UB	CIU	HC	WB
PA	4.870	1.341	0.926	**0.870**										
PR	3.196	1.599	0.963	0.280	**0.946**									
PC	4.008	1.369	0.907	0.498	0.620	**0.842**								
IM	4.170	1.499	0.909	0.507	0.485	0.680	**0.878**							
C	4.314	1.272	0.933	0.436	0.459	0.628	0.547	**0.907**						
PU	4.432	1.379	0.956	0.448	0.421	0.580	0.488	0.738	**0.919**					
S	4.571	1.374	0.976	0.525	0.427	0.647	0.627	0.821	0.705	**0.965**				
UB	4.365	1.533	0.929	0.570	0.469	0.719	0.739	0.652	0.603	0.712	**0.901**			
CIU	4.478	1.447	0.927	0.501	0.443	0.624	0.655	0.765	0.673	0.818	0.739	**0.899**		
HC	5.057	1.212	0.875	0.376	0.179	0.353	0.386	0.342	0.329	0.392	0.444	0.415	**0.799**	
WB	3.770	1.643	0.963	0.490	0.554	0.686	0.613	0.640	0.555	0.660	0.792	0.672	0.362	**0.947**

Table 5.1 - Mean, standard-deviation, CR and Fornell-Larcker

5.2. STRUCTURAL MODEL

To assess multicollinearity, before analysing the structural model, it was performed the variance inflation factor (VIF). There are no multicollinearity issues between variables since all VIF's values are below 3.3 (Sarstedt et al., 2021). R^2 measures and path coefficients' level of significance were used to estimated structural model. To assess this, it was performed bootstrapping with 5000 interactions of resampling. Figure 5.1. shows p-values in parentheses.

The model explains 50.8% of the variation in intrinsic motivation, and perceived autonomy ($\hat{\beta}$ = 0.23; P < .001), perceived relatedness ($\hat{\beta}$ = 0.11; P = .049) and perceived competence ($\hat{\beta}$ = 0.50; P < .001) are statistically significant. Respectively, hypotheses H1a, H2b, and H3c are confirmed. Our model clarifies to 54.4% of the variation in perceived usefulness, and confirmation are statistically significant ($\hat{\beta}$ = 0.74; P < .001). Respectively, hypotheses H3a are confirmed. 69.6% of the variation in satisfaction are explained by structural model, all variables are statistically significant, such as, confirmation ($\hat{\beta}$ = 0.66; P < .001) and perceived usefulness ($\hat{\beta}$ = 0.22; P < .001). Respectively, hypotheses H3b and H4b are confirmed. The model explains 62.6% of the variation in use behavior were intrinsic motivation ($\hat{\beta}$ = 0.58; P < .001) and perceived usefulness ($\hat{\beta}$ = 0.32; P < .001) are statistically significant. Respectively, hypotheses H2a and H4a are confirmed. 73.6% of the variation in continuance intention to use is explained by structural model, intrinsic motivation ($\hat{\beta}$ = 0.12; P = .018), perceived usefulness ($\hat{\beta}$ = 0.14; P = .004), satisfaction ($\hat{\beta}$ = 0.48; P < .001) and use behavior ($\hat{\beta}$ = 0.22; P < .001) are statistically significant. Respectively, hypotheses H2b, H4c, H5 and H6a are confirmed. Finally, our model can explain 65.6% of the variation in well-being were use behavior ($\hat{\beta}$ = 0.62; P < .001) and continuance intention to use ($\hat{\beta}$ = 0.19; P = .001) are statistically significant. Respectively, hypotheses H6b and H7 are confirmed. The moderation effect of health consciousness in the relationship between use behavior and well-being ($\hat{\beta}$ = 0.14; P = .006) is statistically significant but the relationship between continuance intention to use and well-being ($\hat{\beta}$ = -0.06; P = .22), is not statistically significant. Hence, H8a and H8b is confirmed.

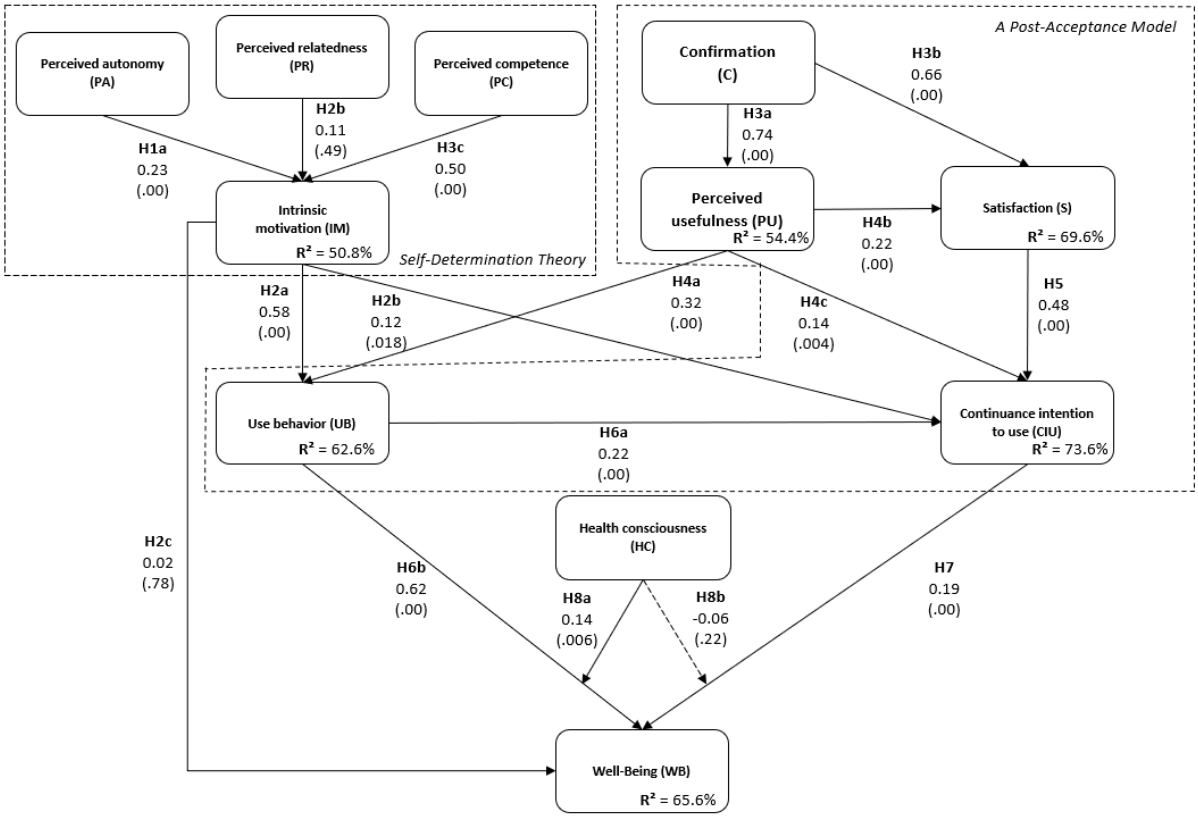

Figure 5.1 - Structural model[1]

[1] In parenthesis are p-value

5.3. MODERATING EFFECT

Health consciousness moderates the intensity of a relationship between use behavior and well-being (Figure 5.2). The hypothesis H8a reflects on the relationship between use behavior, and well-being is weaker for users with low level of health consciousness, rather than users with high levels of health consciousness. Based on this, we can determine that users' use has a greater influence on well-being for users with high health consciousness level. The variation was 65.6% once the moderating effect of health consciousness incorporated the model, to predict well-being, while the variation for well-being would drop to 64.5% without this moderating effect.

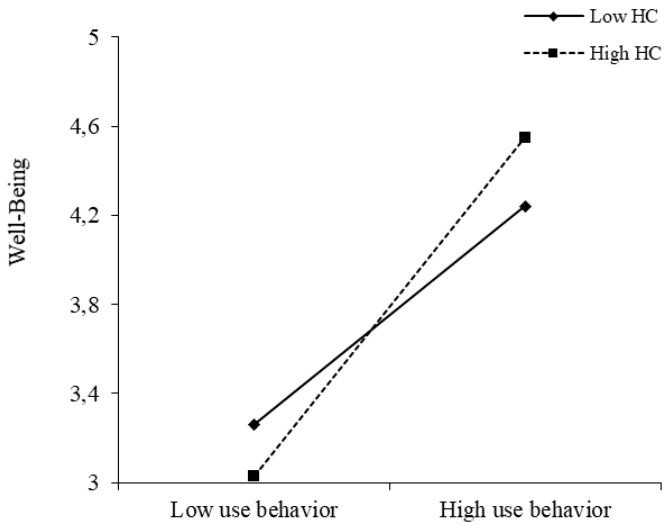

Figure 5.2 - Well-being with moderation between health consciousness (HC) and use behavior

6. DISCUSSION

This study has the purpose to understand the intrinsic motivations on users' use and continuance to use of the mhealth apps through the SDT and PAM. Our study found that users continued use of health apps is significantly influenced by their use of health apps, intrinsic motivation, perceived usefulness, and satisfaction. These inputs project a well-being. Well-being is significantly influenced by their usage of mhealth apps, continuance intention to use and the health consciousness moderate the use behavior-well-being. Although, this study contributes to the academic literature on reasons influencing the intention to continue using mhealth apps that are important role and that otherwise promote wellness and consciousness of health. Also contributes, according to our knowledge, as a new input in the context of the mhealth apps on the relationship intrinsic motivation (IM) between use behavior (UB) and well-being (WB), perceived usefulness (PU) between use behavior (UB), use behavior (UB) between continuance intention to use (CIU), use behavior (UB) and continuance intention to use (CIU) to well-being (WB) with health consciousness (HC) as a moderator.

This research presents the successive theoretical implications. First, perceived autonomy (PA), relatedness (PR), and competence (PC) explain 50% of the variation in intrinsic motivation (IM). Our results support the impact of perceived competence, that was greater than perceived autonomy in the same way as others technology studies (Sørebø et al., 2009; Wang et al., 2021). The users can feel very effective and capable when see the feedback about performance and activity history, feel able to learn new skills and feels more accomplishment about your health. This study extends that competence promoted intrinsic motivation for user's behavior, intention to use mhealth apps and well-being. Second, perceived usefulness (PU), confirmation (C), satisfaction (S), intrinsic motivation (IM) and use behavior (UB) explain 73% of the variation in continuance intention to use (CIU) mhealth apps. This variance explains the increased about through 29 p.p the strength of PAM. In line with Bhattacherjee (2001), satisfaction (S) is the major and strongest predictor, which means that users value more satisfaction with health apps, rather than perceived usefulness (PU) in the intention of continued use of mhealth apps. Although satisfaction-intention, the use behavior (UB) explain 55% of the variation in continuance intention to use (CIU). Oliveira et al. (2021) examined the role of use behavior-intention, however this research expanded it to the continuance intention to use mhealth apps. Third, intrinsic motivation (IM) and perceived usefulness (PU) explain 62% of the variation on use behavior (UB) mhealth apps, were intrinsic motivation (IM) contribute more than perceived usefulness (PU). In addition to the perceived use (PU), the intrinsic motivation (IM) of users' usage mhealth apps, because they are fun and interesting to promote behavior towards having a pleasant experience, to keep health safe for use with more regularity. Fourth, results explain that use behavior (UB) and continuance intention to use (CIU) increase theoretically the predictive power of the well-being (WB), more than intrinsic motivation (IM), where the health consciousness (HC) has a big impact on the specific context of mhealth apps. El Hedhli et al. (2013) examined the factors that promote shopping well-being, but this study extended it to use and continuance intention to use mhealth apps. A positive behavior on use and a continues use the apps can promote a well-being in health. Lastly, we also focused on health consciousness (HC) as a moderator between use behavior (UB) and well-being (WB). This research demonstrates the significant effect of health consciousness (HC) on the specific context of mhealth apps. High level of health consciousness (HC) increases the positive impact of use behavior (UB) on well-being (WB). The model combines several themes that

are present in personal and technological contexts, revealing the benefits of the continued use of health applications.

Regarding practical implications, this study motivates application companies on the best approaches to developing an app, for health-related companies (e.g., hospitals, clinics, insurance companies), government agencies and researchers who are increasingly looking for alternative technologies for their patients, complementary or not to some type of treatment. In this purpose, there are some important points in this study. First, it's important to focus on the intrinsic motivation. Perceived competence has a great influence on intrinsic motivation, so entities will be able to improve/develop features in applications to ensure that mhealth apps meet the motivations for their use by users (Villalobos-Zúñiga & Cherubini, 2020). For instance, apps must give feedback on performance. They should have historical functionality for user understands that they are able to use the app, with the various updates and evolutions of the app's functionalities, where users can learn new skills, etc. Psychological needs motivate the use of mhealth because they are fun and interesting. Along with user motivation, satisfaction is very important to maintain users use the mhealth apps. With this, health-related companies should pay attention to the satisfaction of the users' experience (Nascimento et al., 2018). It is not necessary to constantly update the apps, but it necessarily implies that mhealth apps need to reach the user's expectations. Therefore, companies should continuously develop new health apps that satisfy the needs of mobile devices users (Hur et al., 2017). With these factors, when there is continuous use by users, they can benefit from mhealth apps (Mao et al., 2020), for promote health. However, in this study use behavior was the most impactful factor in the user's well-being with health consciousness as a moderator effect. Well-being is the desired output after continuous use with motivation. In addition to all, the well-being is the output factor that entities should also focus on, and it is the desired output. All applications must provide, in a long term, a social benefit, leisure and increase quality of life, with new features or new developments. For health-related companies, the mindfulness apps are growing popularly as a possible tool to improve well-being (Gál et al., 2021). However, health consciousness was the effect moderator affecting a user's behavior and well-being. Entities should attempt to provide more knowledge in the apps so that the users would like to know more about their health, that they reflect and that they are concerned, with the regular use of the health apps they can bring well-being. Entities may be interested in exploring more the side that promotes consciousness in the health of users, as combined with the use behavior brings well-being. Furthermore, our study confirms that continued usage and behavior usage can promote health and the mobile apps are good tools for this. Finally, this study highlights which factors are important for the continued use of mhealth apps in order to promote user well-being for health.

7. CONCLUSION

The study on the post-adoption of continuous use of technologies has allowed us to realize that other factors are the input and output of this use. Numerous researches on health apps have concentrated on their acceptance, despite a small number of studies have centred on the post-adoption behaviors of using this type of apps. Focusing on this gap, this study promotes continuance theory, developing a conceptual framework that combines the PAM with perceived autonomy, perceived relatedness, perceived competence, intrinsic motivation, use behavior, well-being and health consciousness. By building and checking a model that this study has found that the intrinsic motivation, satisfaction, perceived usefulness, and user behavior have a significant effect on continuance intention. The study also explored that continued use brought well-being and awareness to the user. This model can explain that continue use and use behavior promote a well-being in health.

8. LIMITATIONS AND RECOMMENDATIONS FOR FUTURE WORKS

One of the limitations of this study was the fact that the questionnaire was only carried out in Portuguese, which made it impossible to have a comparison for habits in different regions. Second, the respondents in this study were mainly male and this can be demonstrated by the fact that women are less involved in the use of new technologies (Hoque, 2016). The third limitation was the absence a model or variable that understands the failures or advantages of users when adopting health prevention strategies, whereas applications are used when their purpose is achieved. Lastly, previous research has revealed that behavioral intentions impacts and provides a usage behavior and this study considered only one variable of UTAUT2 model (Venkatesh et al., 2012; Hoque, 2016; Tamilmani et al., 2021).

Future research may test the same model, but in different regions, for example in Asia, which is the region where mhealth apps were most used in 2020 (Buchholz, 2020), to be able to see if a sample of the society follows the same pattern or if it changes certain conclusions. It is advised that following researches tests on both genders, to reach different (or the same) conclusions, as in previous studies (Cho, 2016). In the same order, this model can also be tested only for a certain health area, like many other studies already referenced, fitness apps are the most used (Yuan et al., 2015; Huang & Ren, 2020). In addition, this study can be the starting point to be tested only in specific areas of applications for health, to go deeper into a certain type of application.

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10. APPENDIX

10.1. APPENDIX A – MEASUREMENT ITEMS

Constructs		Items	Adapted from
Perceived autonomy (PA)	PA1	I am free to decide what activities to do while using mobile apps for health in my work/life	Sørebø et al. (2009)
	PA2	I feel like I can pretty much use mobile apps for health as I want to, where I want to	
	PA3	There are a lot of opportunities for me to decide for myself how to use mobile apps in my work/life	
	PA4	I feel like I can make a lot of inputs to deciding how I use mobile apps for health in my work/life.	
Perceived relatedness (PR)	PR1	I feel close to others when I am sharing my performance	Nikou & Economides (2017)
	PR2	I feel connected with my friends/family when I use mobile apps for health	
	PR3	I have the opportunity to be close to others when I use all features in mobile apps for health	
Perceived competence (PC)	PC1	The feedback about my performance tells me I am good at using mobile apps for health in my work/life	Sørebø et al. (2009)
	PC2	When I access my activity history in mobile apps for health, I feel very capable	
	PC3	I have been able to learn interesting new skills in mobile apps through my work/life	
	PC4	Most days I feel a sense of accomplishment for promote my health with mobile apps	
Intrinsic motivation (IM)	IM1	I use the app for health because it is fun	Sørebø et al. (2009)
	IM2	I use the app for health because I enjoy it	
	IM3	I use the app for health because it is interesting	
Confirmation (C)	C1	The experience of using mobile apps for health promotion exceeded my expectations	Bhattacherjee (2001)
	C2	The service level provided by mobile apps for health exceeded my expectations	
	C3	Most of my expectations were confirmed with the use of mobile apps for health	
Perceived usefulness (PU)	PU1	Using mobile apps for health improves my work/life performance	Bhattacherjee (2001)
	PU2	Using mobile apps for health enhances my work/life effectiveness	
	PU3	Mobile apps for health are useful in my work/life	
	PU4	Using mobile apps for health increases my productivity in my work/life	
Satisfaction (S)	S1	I am very satisfied with the overall experience of using mobile apps for health	Xu et al. (2015)
	S2	I am very pleased with the overall experience of using mobile apps for health	
	S3	I am very contented with the overall experience of using mobile apps for health	
	S4ª	I am very delighted with the overall experience of using mobile apps for health	

Use Behavior (UB)	UB1	Using mobile apps for health is a pleasant experience	Alam et al. (2020)
	UB2	I really use mobile apps for health to keep my health safe	
	UB3[a]	I spend a lot of time on mobile apps for health	
	UB4	I use mobile apps for health apps on regular basis	
Continuance intention to use (CIU)	CIU1	I intend to continue using mobile apps for health promote, rather than discontinue its use	Rezvani et al. (2017)
	CIU2	My intentions are to continue using mobile apps for health promote than use any alternative means	
	CIU3	I plan to adjust my work/life to better fit the best practices of mobile apps for health	
Health consciousness (HC)	HC1	I worry that my lifestyle isn't healthy enough	Jayanti & Burns (1998)
	HC2	I reflet about my health	
	HC3	When the matter is my health, I'm very interested	
	HC4	I'm concerned about my health.	
Well–Being (WB)	WB1[a]	Mobile apps have satisfied my overall health needs	El Hedhli et al. (2013)
	WB2	Mobile apps have played a very important role in my social well-being	
	WB3	Mobile apps have played a very important role in my leisure well-being	
	WB4	Mobile apps have played an important role in enhancing the quality of life in my health	

Table 10.1 - Research model items

Note: [a] Eliminated due to low loading.

10.2. APPENDIX B - MEASUREMENT MODEL FOR REFLECTIVE CONSTRUCTS

	PA	PR	PC	IM	C	PU	S	UB	CIU	HC	WB
PA1	**0.835**	0.158	0.322	0.425	0.256	0.259	0.348	0.389	0.325	0.306	0.318
PA2	**0.904**	0.175	0.404	0.461	0.377	0.388	0.469	0.493	0.451	0.318	0.389
PA3	**0.892**	0.271	0.463	0.431	0.419	0.433	0.492	0.531	0.458	0.327	0.440
PA4	**0.849**	0.370	0.542	0.446	0.461	0.475	0.516	0.567	0.505	0.357	0.556
PR1	0.274	**0.923**	0.563	0.424	0.412	0.356	0.386	0.428	0.393	0.168	0.499
PR2	0.261	**0.959**	0.587	0.472	0.427	0.405	0.403	0.447	0.423	0.172	0.531
PR3	0.261	**0.957**	0.609	0.477	0.464	0.430	0.422	0.455	0.440	0.169	0.541
PC1	0.425	0.516	**0.775**	0.496	0.440	0.428	0.457	0.521	0.445	0.195	0.492
PC2	0.446	0.459	**0.845**	0.561	0.503	0.477	0.557	0.584	0.523	0.316	0.556
PC3	0.362	0.575	**0.853**	0.570	0.534	0.484	0.522	0.575	0.503	0.292	0.572
PC4	0.447	0.540	0.890	0.649	0.621	0.554	0.628	0.723	0.615	0.366	0.673
IM1	0.244	0.488	0.531	**0.768**	0.371	0.307	0.400	0.453	0.409	0.229	0.418
IM2	0.494	0.399	0.610	**0.927**	0.515	0.446	0.590	0.717	0.619	0.378	0.577
IM3	0.544	0.420	0.645	**0.928**	0.532	0.505	0.629	0.733	0.661	0.384	0.597
C1	0.409	0.430	0.579	0.517	**0.922**	0.666	0.748	0.586	0.699	0.325	0.565
C2	0.379	0.443	0.594	0.502	**0.928**	0.700	0.745	0.599	0.691	0.305	0.610
C3	0.398	0.376	0.536	0.468	**0.870**	0.640	0.742	0.590	0.693	0.300	0.565
PU1	0.418	0.387	0.523	0.425	0.680	**0.920**	0.638	0.572	0.611	0.343	0.539
PU2	0.406	0.407	0.546	0.454	0.695	**0.941**	0.664	0.566	0.614	0.314	0.527
PU3	0.438	0.337	0.550	0.486	0.662	**0.898**	0.663	0.540	0.650	0.279	0.488
PU4	0.387	0.418	0.513	0.429	0.675	**0.918**	0.628	0.539	0.597	0.273	0.485
S1	0.528	0.390	0.607	0.599	0.790	0.669	**0.964**	0.676	0.792	0.372	0.619
S2	0.518	0.400	0.628	0.613	0.783	0.683	**0.973**	0.689	0.783	0.377	0.639
S3	0.474	0.445	0.637	0.604	0.804	0.688	**0.956**	0.696	0.792	0.385	0.651
UB1	0.593	0.424	0.676	0.761	0.623	0.571	0.715	**0.922**	0.728	0.448	0.715
UB2	0.471	0.468	0.649	0.624	0.587	0.531	0.613	**0.897**	0.652	0.439	0.729
UB4	0.470	0.373	0.618	0.604	0.551	0.528	0.591	**0.884**	0.613	0.306	0.698
CIU1	0.517	0.326	0.545	0.661	0.688	0.568	0.779	0.726	**0.906**	0.409	0.583
CIU2	0.432	0.414	0.566	0.577	0.683	0.586	0.718	0.642	**0.911**	0.342	0.629
CIU3	0.400	0.458	0.574	0.526	0.694	0.661	0.709	0.625	**0.880**	0.368	0.601
HC1	0.230	0.118	0.262	0.237	0.209	0.206	0.294	0.306	0.348	**0.677**	0.269
HC2	0.380	0.126	0.326	0.331	0.287	0.273	0.329	0.380	0.320	**0.855**	0.285
HC3	0.343	0.124	0.292	0.360	0.318	0.300	0.356	0.384	0.340	**0.864**	0.296
HC4	0.244	0.200	0.246	0.298	0.270	0.266	0.272	0.342	0.318	**0.786**	0.302
WB2	0.419	0.553	0.620	0.538	0.612	0.508	0.592	0.701	0.607	0.308	**0.939**
WB3	0.448	0.522	0.667	0.588	0.620	0.541	0.640	0.756	0.645	0.318	**0.955**
WB4	0.520	0.501	0.660	0.612	0.587	0.526	0.640	0.789	0.654	0.398	**0.946**

Table 10.2 - Loadings and cross-loadings for the measurement model[2]

[2] Loadings are the bold line

	PA	PR	PC	IM	C	PU	S	UB	CIU	HC	WB
PA											
PR	0.306										
PC	0.568	0.689									
IM	0.560	0.554	0.789								
C	0.487	0.500	0.711	0.619							
PU	0.488	0.447	0.641	0.535	0.806						
S	0.566	0.448	0.705	0.680	0.887	0.742					
UB	0.637	0.513	0.817	0.830	0.733	0.661	0.769				
CIU	0.562	0.487	0.711	0.741	0.454	0.740	0.888	0.834			
HC	0.443	0.205	0.417		0.402	0.377	0.446	0.522	0.494		
WB	0.532	0.588	0.755	0.675	0.698	0.589	0.692	0.866	0.736	0.414	

Table 10.3 - Heterotrait-Monotrait ratio (HTMT)