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An Empirical Investigation of Mobile Health Adoption in Preventive Interventions

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Abstract
Innovative applications of mobile information and communication technology (ICT) include the recent use of mobile services for preventive health interventions. We report on a one-month empirical study of such an intervention to evaluate a model that includes positive user adoption factors, together with user perceptions impeding adoption. Findings revealed intrinsic motivation to be a sufficient reason for adoption, and a multi-faceted perceived overall risk as the main reason for resisting the new mobile health service.

Keywords: User adoption, motivation, perceived risk, electronic health, mobile health

1 Introduction

Mobile health has gained additional dimensions in recent years with the use of mobile information and communication technology (ICT) services for preventive interventions. One of the approaches considered in several settings worldwide has been the use of short message service (SMS) for sending people various health reminders on their cell phones. Literature reports about experiments where SMS has been used to remind people about upcoming medical appointments (Downer et al., 2005), preventive vaccinations (Anna et al., 2004) or taking medications for long-term self-management treatments (Bauer et al., 2003). Virtually all publications reporting such initiatives did not look scientifically at one key aspect of the picture: user perceptions regarding this innovative use of mobile ICT.

Beyond the potential medical and social gains, the more-or-less complicated technical issues, and the business models regarding the feasibility of such mobile applications, a question remains: what would be the main factors driving people to use or not to use such services? This question is of outmost importance in today's context where there is an emphasis on trying to educate people to use preventive interventions in order to improve health and reduce cost. A focus on consumers or 'acceptors' (Mantzana et al., 2007) of healthcare services is of outmost importance since their perceptions will ultimately determine the success or failure of any such initiative. Further, investigating user acceptance of any ICT at an early stage is a factor favouring its later overall success (Venkatesh et al., 2002).

Consequently, this research tries to fill the void caused by the lack of a scientific perspective on user viewpoints regarding the use of mobile health for preventive interventions. The scope was to propose and validate scientifically a 'pro' versus 'con' adoption model. To accomplish this, an empirical study involving user exposure to a mobile health application for one month was undertaken. After the trial period, user perceptions regarding reasons for and against using such an application were captured and analyzed. In the following two sections we present the theoretical background and research model and hypotheses. Next, we report on the experimental methodology and the main results. Finally, we present a discussion and draw some conclusions and ideas for future research.

2 Theoretical background

Investigating user reasons for adopting and using ICT has a long standing tradition in information systems (IS) research. Several models and theories have been proposed and successfully tested by various researchers (Venkatesh et al., 2003). One of these models is the motivational model (MM) validated in several prominent studies (Davis et al., 1992; Venkatesh et al., 2002).

The motivational model posits that user behavioural intention (BI) to use an ICT application has two key determinants: intrinsic motivation (IM), representing an inherent satisfaction or enjoyment associated with using the technology, and extrinsic motivation (EM) or perceived usefulness, which is related to attaining a goal or obtaining a reward through the use of the technology (Ryan and Deci, 2000). Further, perceiving an activity as enjoyable has a positive impact on the user perceptions of usefulness regarding that activity (Deci and Ryan, 1985).

Although less used than the very popular Technology Acceptance Model (TAM) (Venkatesh et al., 2003), the motivational model is considered more suitable in investigating the innovative use of a new technology in a sensitive domain like healthcare. Whereas TAM is suitable for an established ICT application, the motivational model, capturing user perceptions regarding the goals reachable through a technology use as well as the technology itself, was considered more appropriate for a prospective use of that technology.

The motivational model, as other popular models and theories in IS research, examines factors that would influence positively users to adopt a new ICT application. However, in recent years researchers have acknowledged the existence of other factors that influence users to resist to or reject a new technology. To capture this obstruction phenomenon, researchers have used a multi-faceted perceived risk construct borrowed from consumer behaviour research (Pavlou, 2003). More refined analyses reveal that these negative perceptions usually have several sides: e.g., apprehension about possibly wasting time, fear about wasting money, etc. (Lim, 2003).

Perceived risk has become an increasingly popular construct in IS, being mostly associated with online shopping and its intangibility. To capture the above issues, especially when referring to risk perceptions in the e-commerce context, IS studies have added other facets to those traditional in consumer behaviour research: fear of threats to privacy, apprehension of buying online, etc. (Jarvenpaa and Todd, 1996). Consequently, we considered that in the innovative use of a new ICT in mobile health there may be motivational factors favouring user adoption and risk perceptions disfavouring it. Accordingly, we posed the following research questions:

What is the influence of perceived risk on the motivation to use mobile health for a preventive intervention?

What is the combined influence of risk perception and motivation on the intention to use mobile health for a preventive intervention?

How appropriate is the theoretical model we propose for explaining the intention to use mobile health for a preventive intervention?

3 Research model and hypotheses

We propose a theoretical model that would reflect positive and negative user perceptions regarding technology adoption. These two opposite points of view are best captured through the integration of multi-sided perceived risk into the motivational model.

We captured risk perceptions through a second-order perceived overall risk construct formed by the individual risk dimensions. Since risk perception is context dependent (Conchar et al., 2004), the individual risk dimensions forming the overall risk may vary from one case to another. However, even if the relative importance of the diverse risk dimensions is not identical, their aggregate influence on the overall risk is expected to be about the same (Stone and Grønhaug, 1993).

For this research we assumed that three sides of perceived overall risk play a key role in the adoption equation: financial risk (i.e., fear of wasting money), psychological risk (i.e., fear of making a bad choice), and privacy risk (i.e., fear of losing control of private data). All these express real or virtual threats that users would perceive when subscribing for and using a mobile health service for preventive interventions. Consequently, we hypothesized that:

H1-1: Perceived financial risk is positively associated with perceived overall risk of using mobile health for a preventive intervention.

H1-2: Perceived psychological risk is positively associated with perceived overall risk of using mobile health for a preventive intervention.

H1-3: Perceived privacy risk is positively associated with perceived overall risk of using mobile health for a preventive intervention.

This work proposes as an innovative theoretical approach the integration of perceived overall risk into the motivational model. This is similar to the work of Featherman and Pavlou (2003) who integrated a perceived risk multidimensional construct into the technology acceptance model (TAM). Extrinsic motivation and perceived usefulness represent a single construct which captures the performance expectancy of an activity (Venkatesh et al., 2002). Previous studies showed empirically that perceiving a service as riskier reduces its utilitarian value (Pavlou, 2003; van der Heijden et al., 2005). Consequently, perceiving a mobile service as risky for various reasons (e.g., too expensive, or stressful) is likely to decrease the extrinsic motivation for using that service. Therefore, we hypothesized that:

H2: Perceived overall risk will have a negative effect on extrinsic motivation of using mobile health for a preventive intervention.

Similarly to the influence of perceived ease of use on perceived usefulness that has been consistently demonstrated by TAM studies, evidence show that there is also a relationship between intrinsic motivation (IM) and extrinsic motivation (EM) (Davis et al., 1992). Empirical studies suggest that there is a positive link from IM to perceived usefulness: increasing the enjoyment regarding the fulfillment of a task results in higher quality and productivity. Therefore, it is hypothesized that:

H3: Intrinsic motivation is positively associated with extrinsic motivation of using mobile health for a preventive intervention.

Previous studies in technology acceptance have established that in most cases perceived usefulness is the key determinant of the behavioral intention (BI) to use a technology, while perceived ease of use and enjoyment are secondary antecedents (Igbaria, 1993; Venkatesh, 1999). However, as some studies report, the "more immersive, hedonic aspects of new media play at least an equal role" (Childers et al., 2001). Therefore, fun's positive effect on the use of a technology should not be underestimated. Higher enjoyment leads to higher acceptance (even for unproductive systems), but enjoyment has been seen to have an increased effect on acceptance for systems that are also high in perceived usefulness. An increase in enjoyability increases acceptability "but has less of an effect on the acceptance of useless systems" (Davis et al., 1992).

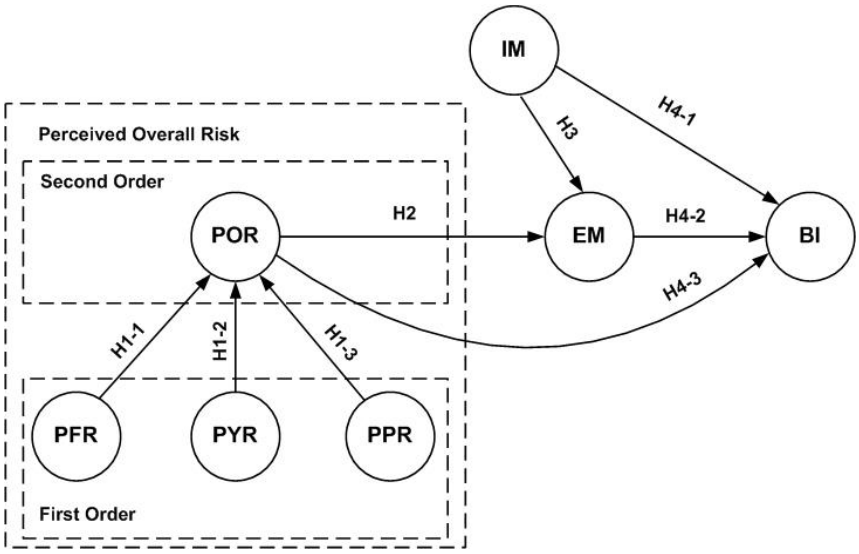
Looking from the opposite side, in general it is habitual for consumers to adopt strategies to decrease risk such as relying on product quality and performance features before making a decision to purchase (Shimp and Bearden, 1982). In particular, for studies in the IS field, perceived risk has been found to play an important role by adversely influencing user intent to adopt ICT-related services (Doolin et al., 2005). Consequently, we hypothesized that:

H4-1: Intrinsic motivation will have a positive effect on the behavioral intention of using mobile health for a preventive intervention.

H4-2: Extrinsic motivation will have a positive effect on the behavioral intention of using mobile health for a preventive intervention.

H4-3: Perceived overall risk will have a negative effect on the behavioral intention of using mobile health for a preventive intervention.

The theoretical model and hypotheses proposed by this research are described in Figure 1.



Note: PFR - perceived financial risk, PYR - perceived psychological risk, PPR - perceived privacy risk, POR - perceived overall risk, IM - intrinsic motivation, EM – extrinsic motivation, BI - behavioural intention to use

Figure 1: Theoretical Model of User Acceptance of Mobile Health for Preventive Interventions

4 Methodology

The experiment described in this study consisted in using SMS on cell phones for a preventive health intervention: reminding people to take a vitamin C pill daily for preventing flu and cold. The study involved 52 participants recruited online from the entire student and non-student population of a North-American university. This experiment was part of a larger project conducted in that setting.

Inclusion criteria required participants to be at least 18 years old and have a cell phone with SMS capabilities. After being presented the benefits of vitamin C from a trusted online source (British Broadcasting Corporation Web site), all participants were required to take one vitamin C pill per day for preventive reasons for one month.

During the experiment, participants received SMS reminders on their cell phones (with fresh content, including brief jokes and interesting related information on how to stay healthy) about taking the vitamins. Reminders were provided by an automated wireless

application at an average rate of one per day, at random times and in an informal language, as sent by a virtual friend.

Data were collected through surveys at baseline (demographics and prior experience with cell phones and SMS) and endpoint of the experiment (perceptions after using the mobile technology effectively). Survey questions used 7-point Likert-type scales and were adapted from previously validated questionnaires in IS (Featherman and Pavlou, 2003; Venkatesh et al., 2002) and consumer behaviour (Stone and Grønhaug, 1993) research.

5 Results

Fifty one participants completed the one-month trial. One case was discarded after a visual inspection detected uncommon patterns in the responses. The remaining 50 cases were used in the subsequent data analysis. Demographic analyses indicated that participants in the experiment were generally young people (average age 24 years), balanced on gender (56% females) and with a significant experience with the technology under scrutiny (average of 4.1 years cell phone experience and average of 2.6 years SMS experience).

The theoretical model was analyzed using the Partial Least Squares (PLS) modeling technique that is suitable for small sample studies when the purpose of the research is exploratory (Chin, 1998), including with formative indicators (Thomas et al., 2005). The 50-case valid sample was larger than the minimum sample of 40 participants required by PLS for the theoretical model used in this research (Jarvenpaa et al., 2004). The PLS analysis comprised two steps: evaluation of the measurement model first followed by the evaluation of the structural model (Bontis, 1998; Jarvenpaa et al., 2004). Operationalization of perceived overall risk was done through the repeated indicators approach (the hierarchical component model) by measuring the second order factor through the indicators of the first order perceived risk facets (Chin, 1997; Lohmoller, 1989).

5.1 Measurement model

A first analysis assessed construct reliability by calculating Cronbach's alpha in SPSS 17.0. Then PLS-Graph 3.00 with bootstrap was run. All the measures were in the expected range except one item of the perceived financial risk (PFR2). This item, displaying very low factor loading and item-total correlation, was dropped from subsequent analyses and the PLS program was re-run. Statistics of the measurement model are presented in Table 1.

Table 1: Measurement Model Statistics

Item	Mean	Standard deviation	Factor loading	Error	Item-total correlations	*t*-value	Internal consistency (Cronbach's alpha; AVE)
PFR1	3.59	1.49	0.952	0.175	0.517	5.43	0.817 (0.679; 0.737)
PFR3	4.21	1.64	0.753	0.254	0.517	2.96	
PPR1	2.38	1.36	0.911	0.025	0.768	36.31	0.984 (0.867; 0.796)
PPR2	2.87	1.68	0.883	0.054	0.753	16.31	
PPR3	2.94	1.62	0.880	0.036	0.739	24.02	
PYR1	1.98	0.94	0.888	0.036	0.730	24.19	0.988 (0.891; 0.823)
PYR2	1.85	1.03	0.924	0.027	0.836	33.95	
PYR3	1.66	0.86	0.909	0.049	0.808	18.54	
IM1	4.53	1.41	0.950	0.024	0.885	39.13	0.991 (0.936; 0.888)
IM2	4.64	1.50	0.939	0.023	0.857	39.44	
IM3	4.49	1.43	0.937	0.031	0.865	30.09	
EM1	4.77	1.72	0.827	0.101	0.721	8.13	0.983 (0.923; 0.821)
EM2	5.27	1.42	0.927	0.039	0.849	23.73	
EM3	5.02	1.62	0.973	0.007	0.936	128.20	
EM4	5.15	1.54	0.888	0.057	0.807	15.44	
BI1	5.61	1.31	0.986	0.007	0.944	140.25	0.997 (0.971; 0.972)
BI2	5.90	1.40	0.985	0.007	0.944	143.69	

Note: PFR - perceived financial risk, PPR - perceived privacy risk, PYR - perceived psychological risk, IM - intrinsic motivation, EM – extrinsic motivation, BI - behavioural intention to use, 1…4 - scale items

Cronbach's alpha and internal consistency values were above 0.7 and average variance extracted (AVE) were above 0.5 for all-but-one constructs, indicating adequate reliability and convergent validity (Fornell and Larcker, 1981). This conclusion was substantiated by high item loading on the factors (above 0.7 for all items), item-total correlations above 0.3 and by the high *t*-values for the item loadings. Cronbach's alpha for PFR with three items was 0.710 but after dropping the PFR2, as suggested by the PLS analysis, it became 0.679. However, the AVE is 0.737 and the internal consistency 0.817. Therefore, the two-item scale for PFR was considered acceptable from the reliability point of view. Consequently, all items in Table 1 were retained in the measurement model (Bontis, 1998; Nunnally, 1978).

A test for discriminant validity is to compare the measurement model construct correlations to the square root of the average variance extracted. Results are shown in Table 2: on the diagonal the square roots of AVE, and off-diagonal the correlations obtained as described by Gefen and Straub (2005).

Table 2: Correlations and Square Root of Average Variance Extracted for First Order Constructs

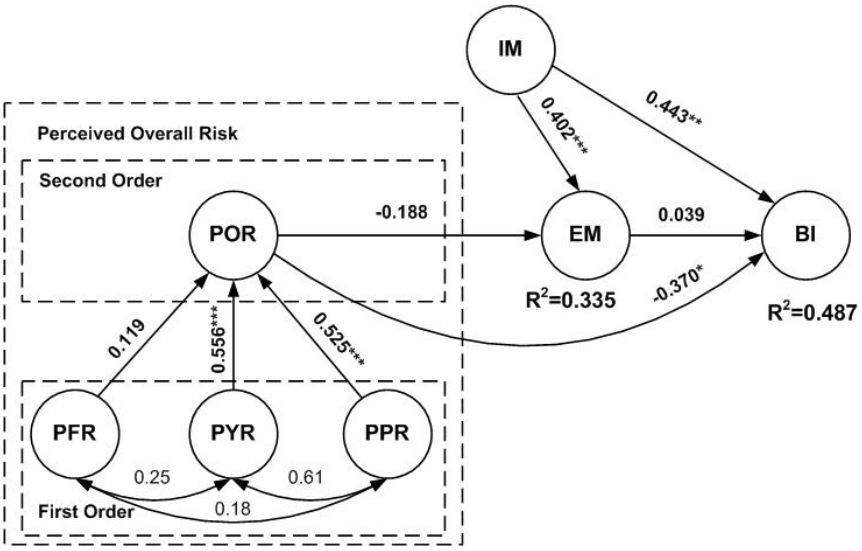
	PFR	**PPR**	**PYR**	**IM**	**EM**	**BI**
PFR	**0.850**					
PPR	0.175	**0.891**				
PYR	0.249	0.606**	**0.907**			
IM	-0.283*	-0.034	-0.189	**0.942**		
EM	-0.378**	-0.021	-0.143	0.554**	**0.906**	
BI	-0.598**	-0.092	-0.200	0.421**	0.602**	**0.986**

Note: PFR - perceived financial risk, PPR - perceived privacy risk, PYR - perceived psychological risk, IM - intrinsic motivation, EM – extrinsic motivation, BI - behavioural intention to use; Significance levels: * = 0.05; ** = 0.01

As the diagonal elements in Table 2 are substantially larger than the corresponding off-diagonal elements, there is some confidence in the model having appropriate discriminant validity (Compeau et al., 1999). In conclusion, after the above analyses, we considered reliability, convergent and discriminant validity conditions were met, so we could proceed to the structural analysis of the model.

5.2 Structural model

Results after running PLS-Graph 3.00 with bootstrap are indicated in Figure 2, together with the correlations between the first-order perceived risk factors.



Note: PFR - perceived financial risk, PYR - perceived psychological risk, PPR - perceived privacy risk, POR - perceived overall risk, IM - intrinsic motivation, EM – extrinsic motivation, BI - behavioural intention to use; Significance levels: * = 0.05; ** = 0.01; *** = 0.001

Figure 2: Structural Evaluation of the Theoretical Model

A visual inspection of Figure 2 shows that most of the hypotheses we made are supported:

psychological risk and privacy risk have a strong significant influence on the overall risk (*H1-2* and *H1-3*);

intrinsic motivation positively influences extrinsic motivation (*H3*); and,

intrinsic motivation affects positively (*H4-1*) and perceived overall risk negatively (*H4-3*) the intention to use mobile technology for a preventive health intervention.

Those that were not supported include: *H1-1* (there is no significant effect from perceived financial risk to the overall risk), *H2* (the influence of perceived overall risk on extrinsic motivation is not significant) and *H4-2* (it cannot be supported that extrinsic motivation has a positive effect on behavioural intention).

In addition, the theoretical model proposed by this research displayed a reasonably high explanatory power. The variance explained by the endogenous constructs was at levels usually met in information systems studies (Moon and Kim, 2001): R^2=0.335 for extrinsic motivation and R^2=0.487 for the behavioural intention.

5.3 Moderator analyses

Demographic variables were tested as possible influencers of the model. Age, gender, and SMS experience were added to the model and PLS was re-run. Virtually no difference

between the R^2 values for the endogenous constructs (EM and BI) with the presumed moderators and without these was detected.

Since technology could do little to support an activity that people do not find important, an additional factor was tested as a possible moderator. This was called *attitude toward adherence* (i.e., the health activity targeted by the mobile service in this case) and was measured with a four-item 7-point Likert scale adapted from validated health research (Horne et al., 2004). The Cronbach's alpha for this construct was 0.797 and AVE 0.518, thus demonstrating satisfactory reliability. When re-running the model with this moderator we noticed slight increases of R^2 for both EM and BI. As loadings and AVE values for the constructs of the initial model did not change when the moderator was added, we concluded that the changes noticed were structural. An analysis of the path coefficients from the attitude toward adherence to the two endogenous variables showed a positive and significant influence (Table 3).

Table 3: Path Coefficients from Attitude toward Adherence to the Endogenous Constructs in the Controlled Model

Control variable		EM	BI
Attitude toward adherence	Path coefficient	0.246	0.222
	t-value	1.922	2.097
	Significance	0.05	0.05

6 Discussion and conclusions

The purpose of this research has been to investigate user acceptance of mobile health for a preventive intervention. We proposed a theoretical model blending both factors favouring adoption (i.e., motivations) and factors disfavouring it (i.e., perceived risk). The model was tested by surveying participants in an empirical investigation where they were exposed to the technology for one month.

The first research question we asked was: *What is the influence of perceived risk on the motivation to use mobile health for a preventive intervention?* In response to this question we found a negative influence of the second-order perceived risk construct on the extrinsic motivation, but this was not significant at the 0.05 level (it was marginally significant at the 0.1 level).

An explanation of this finding could be provided when examining the response to the second research question we asked: What is the combined influence of risk perception and motivation on the intention to use mobile health for a preventive intervention? We found that perceived overall risk was a significant deterrent to the intention to use the technology. This is similar to consumer behaviour research where a risk perception negatively affects consumer intent to complete a purchase (Laroche et al., 2004). We also found intrinsic motivation to influence positively both extrinsic motivation and user intent to use the technology, similar to previous IS studies (Igbaria et al., 1995). However, extrinsic

motivation was not proved to be a significant antecedent of the intention to use the technology.

An explanation of the non-significant role played by extrinsic motivation is that participants were young and normally healthy people who did not perceive the usefulness of a mobile application to support a preventive intervention. Previous research in healthcare has demonstrated that adherence to preventive treatments is the most difficult to ensure because people do not perceive their necessity (Anna et al., 2004).

Nonetheless, even without the contribution of extrinsic motivation, intrinsic motivation was found to be a sufficient reason for adoption. This is similar to some IS studies that found enjoyment more important than usefulness perception (van der Heijden, 2004). This suggests that, when developing mobile ICT applications for health interventions in practice, making these applications attractive may be a sufficient reason for adoption when future goals are not necessarily apparent.

We also found that attitude toward adherence played an important role that deserves more attention in future research. That is, our analysis showed that if people tend to have a positive attitude toward the health activity supported by the technology, they also tend to have a favourable perception of the technology itself.

The last research question we asked was How appropriate is the theoretical model we propose for explaining the intention to use mobile health for a preventive intervention? We found that the majority of the hypothesized model paths were significant, with reasonably high coefficients. We also found moderately high values for the variance explained for the endogenous constructs. According to the literature, these indicate a 'good' model: it has significant relationships between the constructs and high R^2 values (Bontis et al., 2000).

The second-order perceived overall risk construct used three first-order risk facets: financial, psychological, and privacy. While psychological and privacy risk showed a significant and strong influence on the overall risk, financial risk did not show such an effect. Further, this latter risk facet showed low correlations with the other two. A possible explanation to these could be found in consumer behaviour studies which showed that perceived financial risk is so strong in some cases that it plays a role separate from the other risk facets (Stone and Grønhaug, 1993). An alternate explanation is that the possibility of spending additional money for a mobile service was not an issue for people already accustomed to cell phone use. Despite these issues, the model was considered appropriate due to its parsimony and to the possibility of generalization: depending on the context, various risk facets could be added or removed but the general layout would be the same.

This study had some limitations. The relatively small sample size imposed by feasibility was the most important issue. However, the size was 20% more than the minimal number required by PLS techniques. Participants self-selected for the study and were generally young and relatively well-educated people. However they would not differ from the general youthful population in terms of the need for preventive health behaviours. Further, it is always important to look at the future when developing a new information and communication technology; accordingly, this research investigated the perceptions of tomorrow's potential users. Overall, this research did not involve more limitations than those usually encountered in IS studies.

Future research should look more carefully at the integration of the perceived risk into the motivational model. The role of financial risk should be investigated in detail. Another possibility is to consider overall risk as a first-order construct having as antecedents the risk facets as suggested by some consumer behaviour studies (Stone and Grønhaug, 1993). Tests for various risk facets included in the model as well as for several technology contexts should be performed. Obviously, future tests with larger samples and for different user groups would help to assess the validity of the research model proposed here.

This study was an unbiased exploratory investigation of factors favouring or disfavouring the adoption of mobile health for preventive interventions. It is hoped that future investigations will bring more contributions to this type of research, giving perceived obstacles equal importance to factors favouring the adoption of new information and communication technologies.

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