

Acceptance of a Connected Blood Pressure Monitor in the Diagnosis of Hypertension in Rural Areas: An Exploratory Study in France

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Abstract

Home medical devices are increasingly proving their usefulness to the general public, particularly in medical deserts such as rural areas and also in the diagnosis of hypertension (e.g., telemedicine practice requesting self-measurement of blood pressure), nevertheless, this product is not always well received by the population. The objective of this study is to analyze the acceptance of a connected blood pressure monitor in order to understand the factors that will impact its integration in the activity of its appropriation. Twenty patients living in rural areas awaiting diagnosis of hypertension responded to the UTAUT questionnaire after performing self-monitoring of blood pressure for 3 consecutive days. Our results suggest that the intentions of use are related to the 3 main dimensions of the UTAUT, i.e. expected performance (or perceived usefulness), effort expectancy (or perceived ease-of-use), social influence. Effort Expectancy is also strongly correlated to the attitude toward the device. Nevertheless, age, gender, technophilia, self-efficacy and anxiety are not correlated with usage intentions. These results suggest that the intention to use the blood pressure monitor that may impact actual use is determined more by its usefulness (functions, etc.) and ease of use than by socio-demographic characteristics. This is particularly encouraging insofar as these medical devices are a priori accepted by a population with variable characteristics (age, etc.) providing that they are properly designed to be perceived as useful and usable.

Keywords: Acceptance, UTAUT, connected blood pressure monitor, hypertension, mhealth, rural areas

1. Introduction

Home medical devices seem to be a solution to overcome the issues around medical deserts (Eysenbach, 2001; Simon, 2017) and would allow patients to be engaged in their health care (Eysenbach, 2001; Schnall et al., 2016) especially for chronic diseases (Barello et al., 2016). General physicians are among the main people involved in monitoring chronic diseases such as high blood pressure (Lindenmeyer & d'Ortho, 2019). This chronic disease is the most common in the world, affecting nearly one in three adults (Perrine et al., 2018). It is the leading vascular risk factor (Perrine et al., 2018) and its detection still remains complex especially because of the white coat effect (e.g., Spruill et al., 2007). This pathology is today an important public health issue with a necessary optimization of its diagnosis.

Connected blood pressure monitors can be useful in the context of self-measurement of blood pressure proposed in general practice for the diagnosis of hypertension or to control blood pressure in a patient with known arterial hypertension that appears unbalanced (Denolle et al., 2019).

However, these products, previously used exclusively by trained nursing staff, are now in the hands of novice patients (Ten Haken et al., 2018). Simon (2017) showed many obstacles to the use of connected medical devices. Among the major obstacles, there are: data security and invasion of privacy (Allaert, 2016; Béranger, 2014; Laubie, 2011). In the same way, access to these technologies is a major obstacle. Greysen et al. (2014) highlight the inability of some users, especially among the elderly, to access the Internet and a computer. Lack of user skills (Greysen et al., 2014), complexity of use (Carayon et al., 2015; Chaniaud et al., 2021) and certain psychological disincentives to using this equipment such as feeling too old to get started (Chen & Chan, 2011; Simon, 2017) are also important. However, high blood pressure is a disease that primarily affects people over the age of 65 (Mills et al., 2016; Perrine et al., 2018). In addition, Kumar et al. (2015) identified and analyzed 107 applications on self-management of hypertension. The authors found that none of these applications used a blood pressure cuff or had been validated against a gold standard. Similarly, Thangada et al.

(2018) are alarmed at the lack of rigor in the design of blood pressure monitoring devices and supervision systems. Omboni (2019) showed that remote monitoring of blood pressure in hypertensive patients improved patient blood pressure control, especially in rural areas (Dary, 2014). The use of Home medical services such as connected blood pressure monitors are new, innovative and complex especially for the elderly.

Thus, despite the democratization of home connected medical devices, the adoption of these technologies of healthcare services has become a main barrier for their acceptance (Gemert-Pijnen et al., 2011). To our knowledge, no study has investigated the intention to use connected blood pressure monitors in the context of hypertension diagnosis, especially in rural areas. It is therefore crucial to further understand the mechanisms of acceptance and rejection of this type of technology for the diagnosis of hypertension in a rural population. The objective of this paper is therefore to study the acceptance of a connected blood pressure monitor in order to understand the factors that will impact its appropriation by a rural population.

1.1 Unified Theory of Acceptance and Use of Technology

UTAUT (Unified Theory of Acceptance and Use of Technology) is used to study the behavioral intention to use technology and its influencing factors (Liu et al., 2015). Since being introduced, the UTAUT model has been tested extensively in various fields and promises to be a great tool for analyzing users' acceptance of health technology (de Veer et al., 2015; Kohnke et al., 2014a; Liu et al., 2013). Intention to use directly affects use behavior, so promoting intention to use prior to implementation of interventions could facilitate promotion of interventions (Venkatesh et al., 2003a). This model is composed of three dimensions (expected performance, effort expectancy, social influence) impacting the intention to use the device and one dimension (facilitating conditions) impacting the attitude toward the use of technology (Venkatesh et al., 2003a). Thus in view of the previously mentioned literature we can propose 5 hypotheses:

H1 Expected Performance (EP) has a positive impact on intention to use Connected blood pressure monitor (cBPM)

H2 Effort Expectancy (EE) has a positive impact on intention to use cBPM (ID)

H3 Social Influence (SI) has a positive impact on intention to use cBPM

H4 Facilitating conditions (FC) has a positive impact on attitude toward the use cBPM

H5 Intention to use cBPM has a positive impact on Attitude Toward the device (AT).

This model also includes 4 moderating variables that we consider here as independent variables (gender, age, experience and compulsory or voluntary use). Several studies demonstrated the link between high age, low level of education and lack of technophilia on the one hand and difficulties in using connected health devices on the other hand (Huvila et al., 2016). The cBPM is suggested to the patient, so we cannot compare it to an imposed variable. We therefore excluded this last variable. We can suggest 3 other hypotheses:

H6 Age (Ag) has a positive impact on intention to use cBPM

H7 Gender (G) has a positive impact on intention to use cBPM

H8 Technophilia (T) has a positive impact on intention to use cBPM

The UTAUT model is usually supplemented with additional contextual constructs that integrate specific elements of the field of use (Venkatesh et al., 2011). In the case of our study, we are working on a rural population. To our knowledge, no studies based on rural population suggested additional contextual predictors. Nevertheless, we have been inspired by studies of older people or people with little interest in technology (e.g., Cimperman et al., 2016). Two main factors were identified as factor impacting the intention of use in the field of older adults' health technology acceptance: Self-efficacy and Anxiety (Kohnke et al., 2014b). Personal effectiveness has been identified in numerous studies focusing on patient acceptance of health technologies (Breil et al., 2019; Breil et al., 2022; Kohnke et al., 2014b). It refers to the participant's judgement of their ability to use the equipment (Kohnke et al., 2014b). Lastly, anxiety has been identify in studies focusing on older patient and health technology (Cimperman et al., 2016; Kohnke et al., 2014b). Anxiety refers to the participant's self-reported hesitation when using the equipment (Kohnke et al., 2014b). Thus; we can suggest two last hypothesis:

H9 Personal Efficiency (PE) has a positive impact on intention to use cBPM

H10 Anxiety (An) has a positive impact on intention to use cBPM

All these hypotheses allow us to suggest an acceptance model (figure 1)

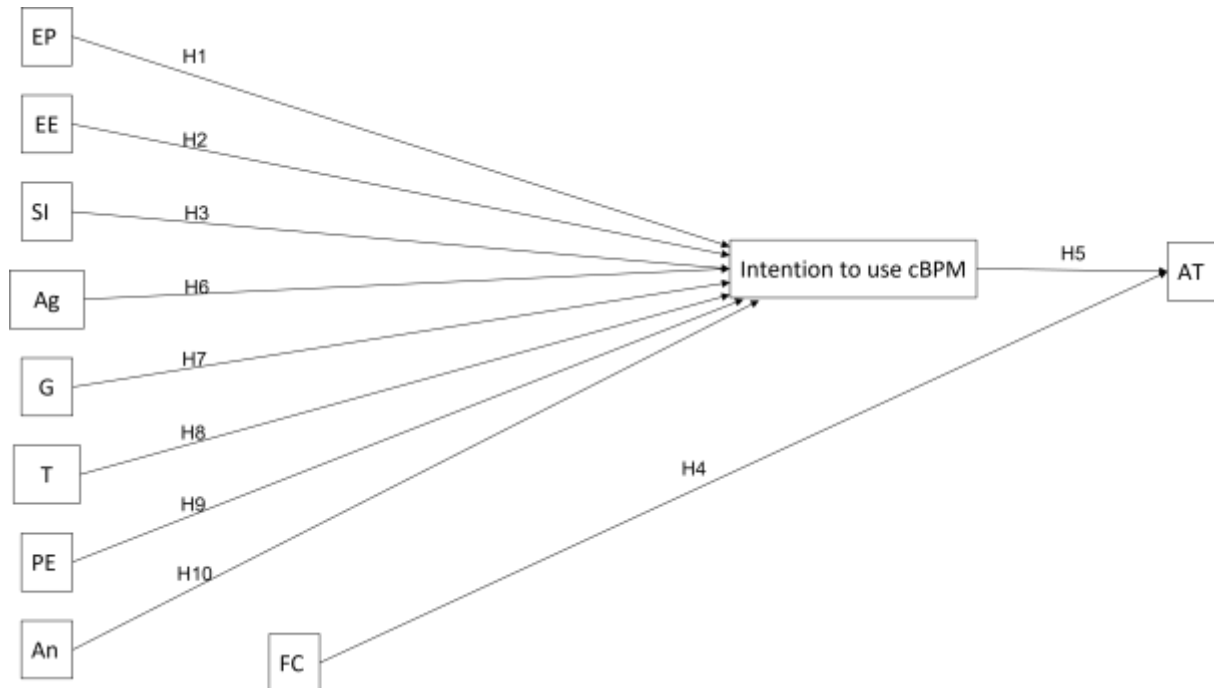


Figure 1. Hypothetical acceptance model of the use of a connected blood pressure monitor in hypertension diagnosis

2. Methods

2.1 Participants

Twenty participants took part in this study and had to be diagnosed with a suspicion of hypertension or a suspicion of a blood pressure imbalance in case of known hypertension. There was no age limit. Patients with significant arrhythmias were excluded from the study on the advice of the blood pressure monitor user manual. Patients with significant cognitive disorders, who could not use the device or complete the questionnaire on their own, were also excluded. The patients all lived in rural areas and had to be familiar with the use of blood pressure self-measurement as a method of diagnosis or monitoring of hypertension.

2.2 Procedure

Five doctors from the Bray-sur-Somme health center, in France, offered connected blood pressure monitors to their patients waiting for a diagnosis of hypertension or for a blood pressure control with known hypertension. During the first consultation, the doctors explained self-monitoring of blood pressure to the patient and explained how the connected blood pressure monitor works. Patient volunteers were asked to take the self-measurement of blood pressure: to record the average of three consecutive measurements of blood pressure in the morning upon rising and in the evening at bedtime, three days in a row. Then, the participants had to complete the UTAUT questionnaire (composed of 17 items). During the second consultation, the patient gave back the blood pressure monitor and the completed questionnaire.

2.3 Material

2.3.1 Blood Pressure Monitor

Participants used a wireless wrist monitor measuring blood pressure (iHealth BP7). The blood pressure monitor, once the measurement is complete, displays the systolic (*SYS*) and diastolic pressure (*DIA*) in mmHg, as well as the pulse rate next to a heart-shaped pictogram with the label *PUL*. The measurements and indicators (in French; eg, bpm) of each device remain displayed for a few seconds. The blood pressure monitor can be coupled with a touchscreen application (smartphone or tablet). A user manual with twelve steps and two illustrations is initially provided with the device.

2.3.2 Questionnaires

2.3.2.1 Sociodemographic Measurements (Age, Education Level, Technophilia, etc.)

This questionnaire includes the following personal details: age, gender, educational level, residential area, technophilia and previous experience with technophilia. Technophilia was measured by 2 items, adapted from Agarwal and Prasad (1998), related to the participant's use of and willingness to explore IT innovations (eg, "Which of these technologies do

you use and how often?”). On a 5-point Likert scale, the possible answers ranged from “never” to “very often”.

2.3.2.2 UTAUT

The questionnaire included 17 items integrating 8 dimensions of the UTAUT. Each item is measured by a 5-point Likert scale (strongly disagree to strongly agree). We present the items in Table 1 below.

Table 1 Constructs and measurement items

Construct	Measurement items	Description
Expected Performance (EP)	EP1	I think it is useful
	EP2	I monitor my blood pressure better with
Effort Expectancy (EE)	EE1	I think it is easy to use
	EE2	I learn to use it easily
Social Influence (SI)	SI1	My family and friends encourage me to use it
	SI2	My doctor encourages me to use it
Facilitating conditions	FC1	I have the knowledge to use it
	FC2	A specific person helps me to use it
Personal efficiency (PE)	PE1	I can use it without outside help
Anxiety (A)	A1	I am apprehensive about using it
	A2	I hesitate to use it for fear of misusing it
Intention to use the device	ID1	I plan to use this device again in the future
Attitude towards the use of technology (AT)	AT1	I find it fun to use

2.4 Data Analysis

Results were analyzed using SPSS software (version 22; IBM Corp). Non-parametric linear correlations, and ANOVAs were performed.

3. Results

Table 2 presents sociodemographic characteristics, technophilia, and previous experience in using a blood pressure monitor. Table 3 presents the results of UTAUT questionnaire.

Table 2. Sociodemographic characteristics, technophilia and experience of the study cohort (N = 20)

Variables	N	%
Age : mean = 53,8 years (SD = 13,91, range_ = 27-83)		
Gender		
Female	11	55%
Male	9	45%
Socio-professional class		
Liberal professions, executives	2	10%
Intermediate professions	1	5%
Public Service Employees	4	20%
Workers	6	30%
Retirees	5	25%
Unemployed	2	10%
Education		
Higher education, 3rd cycle	2	10%
Higher education, 2nd cycle	1	5%
Higher education, 1st cycle	1	5%
Secondary education	16	80%

Health care experience with taking blood pressure		
No	11	55%
Yes	9	45%
Frequency of use of technology (Means, SD)		
Smartphone	2.4 (1.5)	-
Tablette	1.65 (1.65)	-
Computer	2.5 (2.5)	-

Table 3. Spearman correlation matrix (non-parametric correlation)

Factors	EP	EE	SI	FC	Ag	T	PE	An	ID	AT
EP	-									
EE	0.47*	-								
SI	0.3	0.62**	-							
FC	0.35	0.28	-0.63	-						
Ag	-0.23	-0.33	0.04	-0.5*	-					
T	0.11	0.18	0.46*	0.14	-0.39	-				
PE	0.35	0.19	0.14	0.77***	-0.48*	0.2	-			
An	-0.28	-0.42	0.06	-0.6**	0.68**	0.03	-0.54*	-		
ID	0.57**	0.72***	0.46*	0.1	-0.12	0.03	0.13	-0.17	-	
AT	0.36	0.56**	0.11	0.1	-0.17	-0.06	-0.1	-0.14	0.31	-

* $p < .05$, ** $p < .01$, *** $p < .001$

Gender ($F(1,19) = 1.076$, $p = .31$) and previous experience in using a blood pressure monitor ($F(1,19) = 1.076$, $p = .31$) showed no impact on usage intentions.

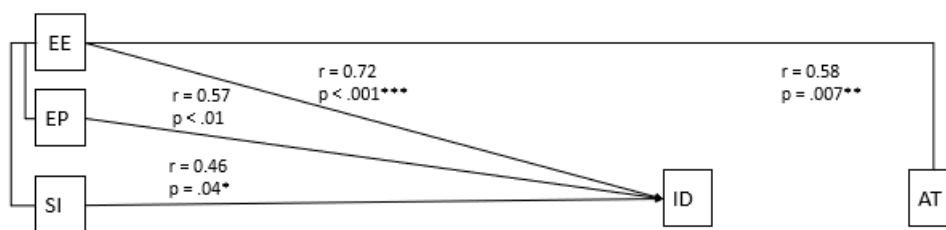


Figure 2. Acceptance model of the use of a connected blood pressure monitor in hypertension diagnosis

4. Discussion

The objective of this paper was to analyze the dimensions of the acceptance of a connected blood pressure monitor in order to understand the factors that will impact its appropriation by a rural population. To do this, firstly, we focused on the classic UTAUT model (Venkatesh et al., 2003) with 6 dimensions (expected performance, effort expectancy, social influence, facilitating conditions, intention to use the device and Attitude toward using the device).

Our first three hypotheses were that expected performance, effort expectancy and social influence would predict the intention to use cBPM. We can validate our first three hypotheses. Expected performance, Effort expectancy and social influence are correlated with intention of use cBPM. Empirical studies highlight the different relationships that exist between these three dimensions (Dwivedi et al., 2020). Usually, perceived usefulness (i.e. expected performance) is the strongest predictor of intention to use. Perceived ease of use (i.e. effort expectancy) has a secondary role : it has an effect on perceived usefulness, and thus an indirect role on intentions to use (e.g., Davis, 1989). The role of perceived ease of use as a direct or indirect predictor of usage intentions is subject to discussion (Yousafzai et al., 2007). Indeed, some studies find a direct effect of this variable on intention of use (e.g., Liu & Yu, 2017; Melas et al., 2011). This could be due to the

field of health or even e-health. Usability would be a central criterion in the acceptance of the device (Carayon et al., 2015) since for the product to be useful, the population must be able to use it correctly. The fourth hypothesis was that facilitating conditions would be correlated with attitudes toward cBPM. We cannot validate this hypothesis. Facilitating conditions refer to the individual's belief that organizational and technical infrastructures make it easier to use the system (Venkatesh et al., 2003b). In the context of our study, the patients were at home. It would seem that they did not project themselves on these organizational and technical infrastructures as facilitating the use of the system. These results could be different in other contexts, for instance in telemedicine practices. The fifth hypothesis was that intention to use cBPM has a positive impact on attitude toward the device. We cannot validate this hypothesis. There is no consensus on this link in the literature. Indeed, there is a gap between the intentions of use and the actual use of a technology (Turner et al., 2010). In our case, patients do not like to use it because it seems not that easy to use, but they intend to use it because they have no choice given the interest and usefulness for their pathology.

The following three hypotheses refer to the moderating variables (age, gender, technophilia) of the Venkatesh et al. (2003) model and the three other hypotheses refer to additional contextual constructs (personal efficiency and anxiety) that integrate specific elements of the field of use (Venkatesh et al., 2011). We cannot validate these six hypotheses. There are several reasons for this invalidation. All integrated variables are usually moderating variables, but we considered these as dimensions i.e., in the same way as the effort expectancy or expected performance. Nevertheless, in table 3, we could observe that none of these variables correlate with the main dimensions of the Venkatesh et al. (2003) model. In addition, all these variables are intrinsic characteristics of the individuals and not characteristics of the device. This is probably due because sociodemographic and patient characteristics are decreasingly related to intention to use or attitudes thanks to the universal designs (Barcenilla & Bastien, 2009) required by medical devices design. The small patient sample with a very homogeneous population may explain the lack of results. A more diversified population in terms of technophilia and age might have allowed to obtain more significant results. Finally, it is also possible that intrinsic characteristics of the patients do not influence cBPM acceptance. Thus, the acceptance of cBPM in the rural population does not depend on either age or technophilia contrary to what Huvila et al. (2016) and Simon (2017) argued. Nevertheless, we observed that age, facilitating conditions, and anxiety are correlated to each other which is in line with studies on technology disincentives in older adults (Simon, 2017).

This study has some limitations. Firstly, the number of participants did not allow the use of more robust statistical techniques such as structural equation models. Nonetheless, the study on rural population is complex to implement and rare. Given the small sample size, the population is not very heterogeneous. We could have obtained more results, especially on the moderating variables. Nevertheless, this is an exploratory study with a representation of the target population and should be conducted on a larger scale to validate all our observations. Finally, the use of health technologies is related to the level of health literacy of patients (Chaniaud et al., 2021). It would have been relevant to add a moderator variable to the models (i.e., health literacy) in future studies using the UTAUT on the acceptance of home medical devices.

In conclusion, our exploratory study showed that the three main variables of the Venkatesh et al. (2003) model are correlated with intentions to use the device. More specifically, it highlighted that perceived usability is a central element in the acceptance of e-health devices. In addition, the intention to use the blood pressure monitor that may impact actual use is determined more by its usefulness (functions, etc.) and ease of use than by socio-demographic characteristics. Intention to use the device may have an impact on actual use, which is determined more by the intrinsic characteristics of the device than by socio-demographic characteristics. This is particularly encouraging as these medical devices are a priori accepted by a population with various characteristics (age, etc.) provided that they are properly designed to be perceived as useful and usable.

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