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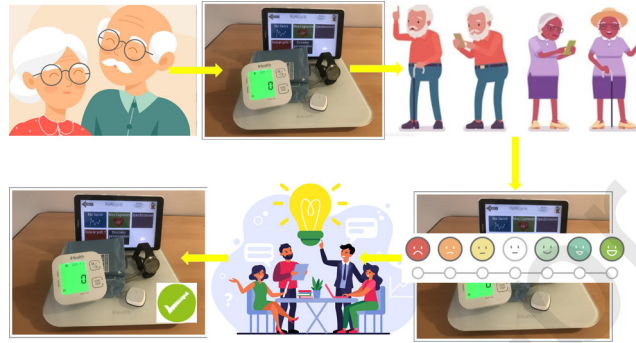


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## Graphical abstract

***A priori* acceptability of a multimodal system for the early detection of frailty in older adults**

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## Highlights

- Poor prior experiences with NTIC don't alter the intention to use the ACCORDS system.
- *A priori* acceptability and intention to use are rather favorable to the system.
- Good acceptability seems to be conditioned by ease of use and near perfect functioning.

Journal Pre-proof

# *A priori* acceptability of a multimodal system for the early detection of frailty in older adults\*

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## ABSTRACT

**Introduction:** Frailty would affect 4 out of 5 people aged of 85 and over in France.

**Methods:** As part of a global project aimed to develop a multimodal system for the early detection of frailty among older adults living at home or in independent senior living apartments, we reported prospective quantitative study assessing a priori acceptability of this system based on Bel's integrative model devoted to the behavioral prediction use of an unknown technology. The platform is composed of 5 devices: a weight scale, a tensiometer, a wrist-worn step counter, an activity tracker and a tablet to exchange data with the aforementioned sensors over the internet. The inclusion criteria are: age  $\geq 80$  years old, living at home or in independent senior living apartments, assessed as 'robust' or 'pre-frail'. The a priori acceptability is assessed through self-evaluation questionnaires, mainly using a continuous scale (min-max score 1-7).

**Results:** We included 34 volunteers (24 women and 10 men), mean age 85.6 years ( $\pm 4.1$ ), 24 of whom were classified as 'robust' and 10 as 'pre-frail'. A priori utility of the multimodal system (mean score = 6.0 ( $\pm 0.9$ )), a priori intention of use (mean score = 5.9 ( $\pm 0.8$ )) and the rate of recommendation of the device before its first use (82.4 % ( $\pm 17.4$ )) were clearly in favor of the device.

**Conclusion:** This study is in favor of an a priori acceptability and an a priori intention to use rather favorable to the developing system. Those results point a need for significant ease of use and almost-perfect functioning of this connected system for good acceptability.

## 1. Introduction

As of 1 January 2021, the French population was estimated at 67,407,241, of which 9.5% were aged 75 and over and 3.4% were aged 85 and over [15]. The proportion of people aged 75 and over living at home is 90% [17]. Among them, 83.1% are considered independent [16]. The French National Institute for Statistics and Economic Studies estimates that in France, in 2060, the proportion of people aged 75 and over would be 16.2%, *i.e.* about 12 million individuals [19]. Most of French people express their desire to 'age' at home [11]. However, the risk of falls threatens this lifestyle choice. Indeed, falls are known to be the third most common cause of hospital admissions in acute medicine departments and the leading cause of fatal accidents among older adults [18, 21].

One of the main risk factors for falls is the 'frail status' [22, 20, 7, 8, 27, 10]. Among approaches used to diagnose frailty syndrome, the phenotypic-type approach of Fried et al. [22] is one of the most frequently cited in international studies devoted to this concept [20, 7, 8, 10, 13]. According

to Fried's frailty phenotype, people can be classified as 'robust', 'pre-frail' or 'frail', depending on whether they meet respectively none, one or two, or at least three of the following criteria: unintentional weight loss, self-reported exhaustion, slow walking speed, weakness (grip strength) and low physical activity [22, 20, 7, 8, 10, 13]. There is a continuum between the state of 'robustness' and the state of 'frailty', passing through a state known as 'pre-frailty' [22, 20, 7, 24, 30]. According to the European Survey of Health, Ageing and Retirement in Europe (SHARE), 9% of people aged 50 and over in France could be considered as 'frail' and 41% as 'pre-frail' [37]. The proportion of people aged 75 and over who are 'frail' and 'pre-frail' could be around 15% and 50% respectively. At the age of 85, less than one person out of five could be considered as 'robust'. The state of 'frailty' would increase the risk of falling (Hazard ratio (HR) = 1.23; Confidence interval (CI) 95% [1.50- 2.21]), of loss of functional independency (HR = 1.79; 95% CI [1.47- 2.17]), hospitalization (HR = 1.27; 95% CI [1.11- 1.46]), and death (HR = 1.63; 95% CI [1.27-2.08]) at 2 years compared to people considered as 'robust' [22, 20, 7, 8, 44].

The World Health Organization recommends a "proactive identification of older people in the community at risk of frailty" to provide "opportunities to intervene and so prevent or delay functional decline". Thus, we recently proposed the use of a multimodal health monitoring system for the early detection of elements linked to Fried's frailty, within a project presented in the next section. One of the key assumptions of this approach is that older citizens will

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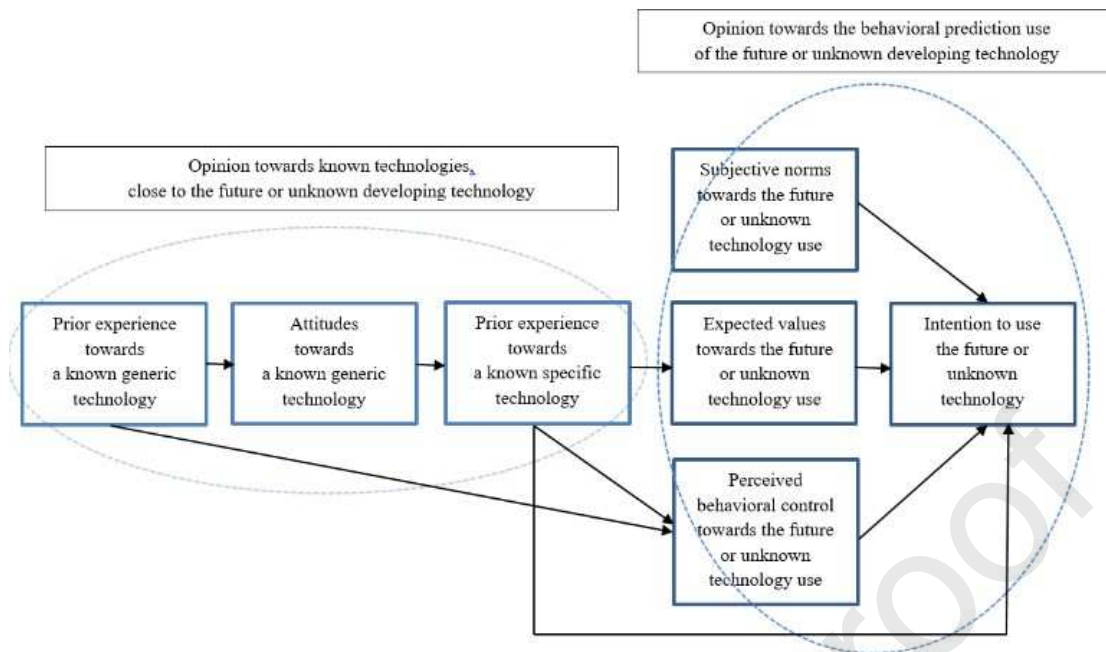
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**Figure 1:** Bel's integrative model of the behavioral prediction use of an unknown technology, adapted from "Bel M. Predicting the use of a new technology: the case of Cooperative Intelligent Transport Systems. 2016".

use this information and communication technology (ICT)-enabled device. However, the development of ICTs is not always successful [41, 3, 34, 35, 38, 25]. From this 'proof of concept' phase, we have developed an ancillary study to assess the acceptability of ICTs among older individuals.

In contribution, we present the results of the *a priori* acceptability of the system through the prism of Bel's integrative model, evaluated on the day of the inclusion of volunteers in the research protocol.

## 2. Methods

### 2.1. Bel's Integrative Model

In this work, we used a theoretical framework that proposes to explore acceptability in several sub-dimensions [41, 3]:

- *A priori* acceptability: this is the set of representations that individuals have of a future or unknown technology. Those representations will influence and participate in the individual's decisions to whether or not use this technology in the future.

- The model is also designed to assess acceptance and appropriation, which were not used in our study.

The two most frequently used models in the literature concerning the acceptability of a new technology are Davis' TAM model and Venkatesh' TAUT model [43, 26, 23]. Another model, named UTAUT2, has been recently developed from TAM and UTAUT models. It is regularly adapted to technologies under development, as recommended in the original study by Venkatesh et al [43, 31, 32, 1]. Bel's model was developed for the analysis of the intention-to-use of

autonomous vehicles. Our team chose to use this emerging model because it incorporates a theoretical framework that includes components tending to explain the *a priori* acceptability of a multimodal system, composed of connected sensors intended for the early detection of frailty in older adults [4, 36]. Indeed, this model has the advantage of targeting the attitude measurement not on the specific device, sometimes unknown to our participants, but on a more generic category (information and communication technologies), on which our subjects have a representation. This allows to refine the measure of acceptability. A comparison of UTAUT2, TAM3 and Bel's model, identifying the main similar and specific characteristics is shown in Table 1. The definition of the similar characteristics is derived from the TAM. This theoretical framework is the oldest of the 3 and has helped structure the following frameworks in part.

It should be noted that some authors do not rely on a particular theoretical framework for the analysis of acceptability as shown in several reviews [2, 6, 12, 39]. As an example of studies included in those reviews [9, 29], the evaluation of user satisfaction can be investigated by a Likert scale, but outside of any traditional framework for studying the acceptability of a new technology. In the same way, interviews can be conducted to better understand acceptability without necessarily relying on these theoretical frameworks [33]. Finally, comparison and assimilation of acceptability with time in use of a device is an indirect way to assess acceptability [40].

The 2016 Bel's integrative model of the behavioral prediction use of an unknown technology [3] is based on traditional models of technology acceptability: the 1980 Ajzen

**Table 1**

Comparative table of UTAUT2, TAM3 and Bel's model, identifying the main similar and specific characteristics

	<b>UTAUT 2</b>	<b>TAM 3</b>	<b>Bel's model</b>
<b>Similar characteristics</b>	Social influence	Subjective norms	Subjective norms
	Effort expectancy	Perceived ease of use	Perceived behavioral control
	Performance expectancy	Perceived usefulness	Expected values towards the future or unknown technology use
<b>Specific characteristics</b>	Habit <i>i.e.</i> routine using the internet	Computer self-efficacy	Prior experiences towards known generic or specific technologies

- Subjective norms: The degree to which an individual perceives that most people who are important to him/her think that he/she should or should not use the system (Fishbein & Ajzen, 1975; Venkatesh & Davis, 2000).

- Perceived ease of use: The degree to which a person believes that using an IT will be free of effort (Davis et al., 1989).

- Perceived usefulness: The degree to which a person believes that using a particular system would enhance his or her job performance (Davis, 1989, p. 320).

and Fishbein's theory of reasoned action, the 1985 Ajzen's theory of planned behavior, the 1989 Davis' technology acceptance model, the 2003 Rogers' diffusion of innovation theory, and the 2003 Venkatesh et al.'s unified theory of acceptance and use of technology [41, 3, 34, 35]. Although it does not take into account all the dimensions related to acceptability, Bel's integrative model emphasizes "the existence of a predictive chain [of influencing factors] ranging from a known generic technology that is conceptually close to the unknown technology, to increasingly specific technologies, leading to the prediction of the intention to use [...] the technology that does not yet exist" [3]. The intention to use aims to "anticipate" the use of this future or unknown developing by users [3]. This model is shown in Figure 1.

## 2.2. The ACCORDS multimodal system

The Signal and Image Processing Laboratory (LTSI), French National Institute of Health and Medical Research - Unit 1099 of University of Rennes 1, the Geriatrics Department of Rennes University Hospital Centre, and the Clinical Investigation Centre - Technological Innovation 1414 of Rennes University Hospital Centre, have joined forces with the industrial companies RF-Track and AZNetwork to develop a multimodal platform for collecting data related to frailty. This project is named ACCORDS, a combinatory approach of connected functionalities for the collection of health data with multimodal aims. Its main objective is to develop a solution for the early detection of frailty of older people, thanks to the collection of clinical data, associated with paraclinical data obtained through the multimodal platform.

The present study assesses the *a priori* acceptability of this system by older adults. It was carried out on the basis of collaborative and interdisciplinary work, from its design to its implementation, both in terms of choice of the collected parameters, the development of algorithms and interfaces and in the development of the research protocol for the present study on the ICTs' acceptability. The whole project received funding from the French National Research Agency

in 2018 for a period of 4 years.

The device is entrusted to the volunteer for a maximum of 2 years, to be used in his/her daily living. It is composed of:

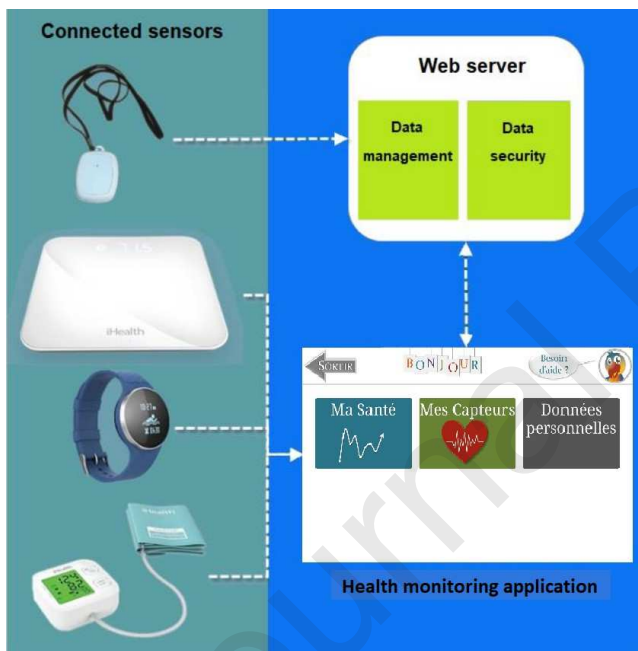
- a connected weight scale (iHealth HS2 and HS2S), to monitor the subject's weight, to be used at least twice a month,
- a connected blood pressure monitor (iHealth Track KN-550BT), to monitor blood pressure and heart rate, to be used at least once a month,
- a wrist-worn step and calories counter (iHealth AM4), integrated into a wristwatch, to monitor the subject's activity via the number of daily steps, the estimated energy expenditure and the daily travelled distance, to be used at least 15 days, consecutive or not, per month,
- a sensor for quantifying physical activity called 'activity tracker' (manufactured by the company RF-Track) comprising an accelerometer, a barometer and a radio transceiver, which can be worn around the neck or the waist, to be used at least 15 days, consecutive or not, per month,
- a touch tablet (Samsung Galaxy Tab A 2016, Android 6.0 operating system) allowing access to a health monitoring application for the above-mentioned parameters, which is accessed by the subject at least once every two weeks.

The health monitoring application called Calliopé® was specially developed for this study, based on collaborative work within the team. It allows data to be retrieved from the 3 iHealth sensors, secure data connection and storage, as well as the visualization of the daily data history for the volunteer. At this stage of development, the text of the application is in French since it is intended for a cohort of French individuals. It has not yet been translated into English. This platform is shown in Figure 2. The functioning of the multimodal system is shown in Figure 3. For these two figures, the menu titles are: "Ma santé" for "My health"; "Mes capteurs" for "My sensors"; "Synchroniser" for "Synchronizing"; "Données personnelles" for "Personal data"; "Suis-je prêt ?" for "Am





**Figure 2:** The ACCORDS platform including a weight scale, a tensiometer, a wrist-worn step and calories counter, an activity tracker and a tablet using the Calliopé® application.



**Figure 3:** Functioning of the ACCORDS multimodal system allowing health monitoring via the Calliopé(c) health application.  
→ Communication through the multimodal system.

I ready?"; "Besoin d'aide ?" for "Need help?"; "Sortie" for "Exit".

### 3. Clinical trial

The project received a favorable opinion for its implementation from the Protection of Persons Committee West VI - 1228 HPS2, under the code IDR CB 2019-A02316-51 on 2 January 2020. The French National Commission for Information Technology and Civil Liberties and the French

National Agency for the Safety of Medicines and Health Products have been informed of this study. The duration of the inclusion period is 12 months from 1st September 2020. The estimated data processing time is 6 months. The total duration of the study is 54 months, including a 6-month extension of the study due to the SARS-Cov 2 epidemic.

#### 3.1. Participants

Considering the recruitment campaign, the diversity of the older adults' profiles, the number of prototypes that can be produced by the end of the clinical study, we estimated that a minimum of 30 evaluable individuals is an adequate number to test the validity of the material. Furthermore, we investigated adults aged 80 and over as the likelihood of becoming pre-frail or frail over the next two years is higher than in younger adults. The inclusion criteria for the project were: age ≥ 80 years old, living at home or in independent senior living apartments, assessed as 'robust' or 'pre-frail' according to Fried's frailty phenotype. The criteria for non-inclusion were: hospitalization in the month preceding the first visit, cognitive impairment prohibiting proper use of the system, inability to give consent to participate in the study, or being subject to legal protection [42]. If the person is classified as 'frail' (3, 4 or 5 Fried's criteria) during the follow-up, the health monitoring is concluded so we can analyze his/her frailty trajectory and the criteria that could indicate the onset of frailty at an early stage.

#### 3.2. Calendar of home visits

We propose a set of 10 home visits over 2 years. The first inclusion took place on September 2020. In the framework of the SARS-Cov 2 pandemic, the barrier measures were respected during home visits.

#### 3.3. The collection of data for the a priori acceptability study

Volunteers were met with their agreement at their own home. The information letter and the consent form to participate in the study were read by a psychologist and/or a geriatrician working on this project. These documents were submitted to the ethics committee for approval. The information letter provided information, noted point by point, concerning the course of the study, its objectives, the conditions for inclusion, non-inclusion and exclusion of participants, its potential benefits and risks, and its timetable. After signing the consent form, the five connected sensors of the ACCORDS system were presented to the participant. The sensors and the Calliopé© health monitoring application were shown to the participants. The global functioning of the ACCORDS multimodal system, the potential usefulness and mode of operation of each device, and the functioning of the Calliopé© health monitoring application were explained, one at a time. Volunteers did not manipulate the sensors at this time. The questionnaires concerning the a priori acceptability of the system were submitted to the volunteer immediately afterwards.

**Table 2***A priori* acceptability of the system

<i>A priori</i> acceptability themes	Questionnaire's scores	
	Mean scores (SD)	Min-Max scores
Prior experience towards ICTs	3.8 ( $\pm$ 1.1)	1 - 7
Prior experience towards health monitoring technologies	3.9 ( $\pm$ 1.3)	1 - 7
<i>A priori</i> attitudes towards ICTs	4.6 ( $\pm$ 1.3)	1 - 7
<i>A priori</i> utility of the system	6.0 ( $\pm$ 0.9)	1 - 7
<i>A priori</i> usability of the system	5.0 ( $\pm$ 0.9)	1 - 7
<i>A priori</i> comfort of use	4.6 ( $\pm$ 1.6)	1 - 7
Influence of family members and friends in initiating ICT's health monitoring	5.5 ( $\pm$ 1.5)	1 - 7
<i>A priori</i> intention to use the system	5.9 ( $\pm$ 0.8)	1 - 7
Overall rating of the system at the time of inclusion	8.0 ( $\pm$ 1.3)	1 - 10
Rate of recommendation of the system to family members or friends at the time of inclusion	82.4 ( $\pm$ 17.4)	0 - 100

ICTs: Information and communication technologies

SD: Standard deviation

The quantitative part of the *a priori* acceptability study presented here is based on four self-evaluation questionnaires constructed from data in the literature, in particular Bel's integrative model of behavioral prediction of the use of an unknown technology, and reflections of our research team [41, 3, 34, 35]. These questionnaires include 46 items grouped into eight themes. The items are assessed using a continuous scale. The first 15-item questionnaire explores three themes: the person's prior experience and attitudes towards information and communication technologies, and prior experience with health monitoring technologies. The second questionnaire of 12 items explores three themes: the 'expected values of the use of the object' also called a *a priori* utility; the 'subjective norms', meaning the influence of family and friends in initiating ICTs' health monitoring; and the *a priori* intentions to use the system. The third 9-item questionnaire explores one theme, the *a priori* comfort of use. Eventually, the fourth questionnaire of 10 items explores one theme, the 'perceived behavioral control' also called the *a priori* usability of the system. The seven possible response options cover the spectrum of opinions, from 'strongly disagree' to 'strongly agree'. For each item, a score is obtained, ranging from 1 for 'strongly disagree' to 7 for 'strongly agree'. For negative sentences, the score is reversed. Then, the participant is asked to give an overall rating of the system out of 10 at the time of inclusion. The scores' means ( $\pm$  standard deviation) were calculated. The closer the mean score is to 1, the more negative the assessment is considered to be. The closer the mean score is to 7, the more strongly the assessment is considered to be positive. About the last item, the participant is asked to give a rate of recommendation of the system to his/her family members and friends at the time of inclusion. The questionnaires assessing the acceptability of the multimodal system are available as supplementary materials. The data were recorded using Microsoft Excel (2010) ® software.

## 4. Results

### 4.1. Characteristics of the population

Thirty-four volunteers were included in the study. The mean age was 85.6 years ( $\pm$  4.1). There were twenty-four women and ten men. According to Fried's criteria, 20 volunteers were classified as 'non-frail' and 14 as 'pre-frail'. Twenty-one participants lived in their own house and thirteen in a senior residence. The majority of the participants belonged to a higher socio-professional category. All participants completed all questionnaires.

### 4.2. Questionnaires on the *a priori* acceptability

On average, volunteers expressed an average opinion on their prior experience towards ICTs (mean score = 3.8 ( $\pm$  1.1)) and prior experience towards health monitoring technologies (mean score = 3.9 ( $\pm$  1.3)). While they all had a mobile phone, they did not all have a computer or a tablet at home. Older adults living in their own homes were more often equipped with ICTs than individuals living in independent senior living apartments. Overall, *a priori* attitudes (mean score = 4.6 ( $\pm$  1.3)), *a priori* usability of the device (mean score = 5.0 ( $\pm$  0.9)), *a priori* comfort of use (mean score = 4.6 ( $\pm$  1.6)), and the influence of friends and family in initiating health monitoring using ICTs (mean score = 5.5 ( $\pm$  1.5)) were rated in an average to a good way. Moreover, *a priori* utility of the multimodal system (mean score = 6.0 ( $\pm$  0.9)), *a priori* intention of use (mean score = 5.9 ( $\pm$  0.8)), the overall score out of 10 (average score = 8.0 ( $\pm$  1.3)) and the rate of recommendation of the device before its first use (82.4 % ( $\pm$  17.4)) were clearly in favor of the device. This could be explained by the positive feeling of participating in a research protocol, and the excitement of novelty and discovery [14]. The results of the *a priori* acceptability of the system are summarized in Table 2.



## 5. Discussion

This study underlines the modulation of the *a priori* acceptability of an information and communication technology, according to different factors as presented in the 2016 Bel's study. Indeed, according to Bel: "prior experience towards known generic objects indirectly predicted the intention to use the unknown object, via mediation by attitudes towards generic objects, prior experience with specific objects and value/expectations towards the use of the unknown object". Conversely, we reported in the present study that moderate rating of prior experience with known generic and specific objects did not appear to alter participants' intention to use it. As reported in Bel's study, our results also highlighted the indirect influence of the subjective norm [mainly the influence of the social environment] on the intention to use this developing technology [3]. Furthermore, the *a priori* comfort of use was evaluated as rather good, but the large number of connected sensors (in this case 5) brought to the person at the same time during the first home visit may explain why the opinion expressed is not as favourable as the *a priori* utility.

The strengths of this study lie firstly in the assessment of the acceptability of an information and communication technology in a population of people aged 80 and over, rarely explored in the literature [25]. Furthermore, the system is unique in that it is evaluated immediately with the target audience. Indeed, in 2013 Quiguer explained that "by remaining 'impervious to the reasoning that can be deployed in an ecological environment' (Reerink-Boulanger, 2012, p.104), the knowledge developed through the completion of these questionnaires does not provide the critical content on which to act in order to allow effective appropriation of the systems, which remains the goal of any technological implementation" [34]. Overall, user involvement from the start of the design phase of a new technology is essential, so designers can improve the development of the technology at the very beginning of the developing process. Moreover, in this way, older users can develop empowerment and so their well-being [14, 5]. Thus, the acceptability of interventions in health promotion and prevention would be improved by the integration of individuals throughout the project process [38].

The main limit of this study is the intrinsic limits of theoretical models of acceptance that helped to develop the acceptability questionnaires. According to Bobillier-Chaumon and Dubois in 2009, "new technologies include change factors that cannot always be anticipated *a priori*". The use of quantitative questionnaires alone does not always reflect real-life situations, and the mean scores obtained from the questionnaires do not usually reflect the reality of the heterogeneity of people, particularly older adults [41, 28]. Furthermore, in this preliminary study we were on a "proof of concept" design and we could not assess the real cost of the solution. We believe that the cost is moderate because most of the components are quite easy to buy in sell stores.

Nevertheless, the cost-utility ratio of the solution should be assessed in view of assessing the implementation of the solution in real market. Moreover, we decided to lead a parallel prospective qualitative study assessing acceptability of the system to obtain new perspectives of this topic. The qualitative method helps to understand social practices and their issues. It allows to study the meaning that respondents give to a phenomenon - in this case, the motivations for using a multimodal system made up of connected objects aimed at early detection of frailty and its acceptability - and helps to analyze the factors that facilitate or limit the implementation of an intervention. Furthermore, there is no evidence at this point that frailty score has an effect on acceptance factors. The potential link between frailty status and acceptability of a frailty detection technology needs to be analyzed in future study.

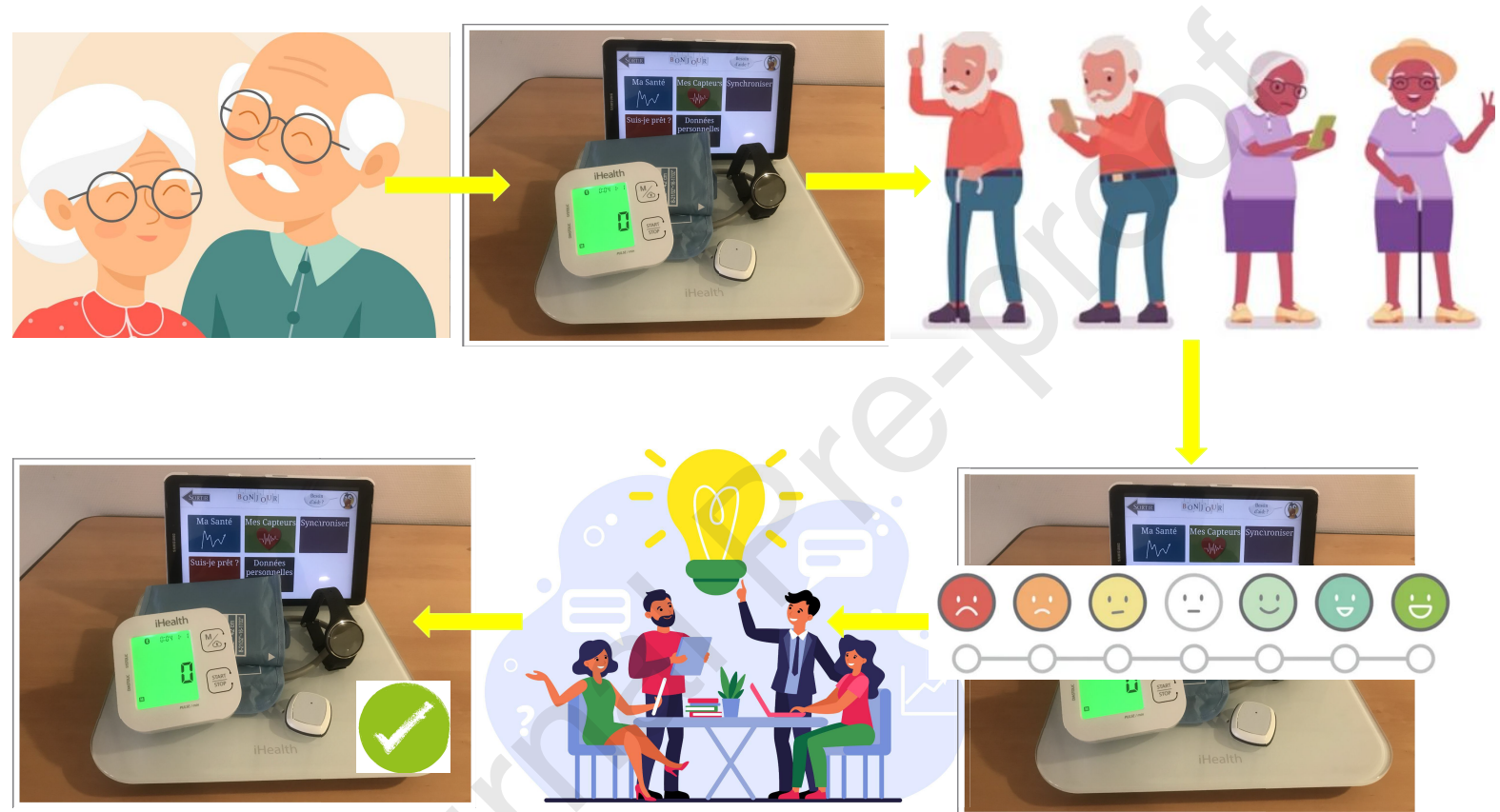
## 6. Conclusion

The results shown in this study are encouraging and in favor of an *a priori* acceptability and an *a priori* intention to use rather favorable to the developing system. The large number of connected sensors (in this case 5) brought to the person at the same time during the first home visit may explain why the *a priori* comfort of use expressed is not as favourable as the *a priori* utility. Those results point a need for significant ease of use and almost-perfect functioning of this connected system for good acceptability. Whereas they are not totally consistent with Bel's model, those results allow the study to be continued by enriching this model used as a reference in this project and to better understand the actual use of the system beyond its *a priori* acceptability.

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## Author responsibilities, integrity, ethics



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