Evaluating End-User Perception Towards a Cardiac Self-care Monitoring Process

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Abstract. This study examined the perception of end-users regarding the monitoring process offered by an innovative cardiac self-care system. The main goal was to assess the efficacy of the process implemented by a smart device designed to support people for real-time monitoring of cardio-vascular parameters in everyday life, thereby encouraging patients to be more proactive in heath management. Most participants showed positive response about the potential benefits of the proposed self-care solution and were willing to adopt the system despite some concerns related to trust and privacy.

Keywords: Ambient assist living · Personal healthcare · Pervasive monitoring · Remote diagnosis

1 Introduction

More than half of all deaths across the European Region are caused by Cardiovascular disease (CVD). In 2017, the European Parliament Heart Group identified CVD as the major cause of death, killing over 2 million people each year in Europe alone[1]. In principle, CVD patients can lead a normal life as long as they are continuously monitored and alerted to the emergency services in case of abnormal situation. Hence the regular monitoring of vital signs, such as heart rate, is the basis to detect a risk level of cardiovascular disease [1].

In recent years the development of self-care monitoring solutions have shifted the monitoring process from the traditional event-driven mode (i.e., when a specific change in patient condition leads to a medical intervention, such as admission to hospital) to a new scenario where the patients use personal self-care devices to monitor continuously their vital parameters directly at home, through smart-home technologies [2–4]. The use of self-monitoring systems can provide assistance without limiting or disturbing the patient's daily routine, giving greater comfort and well-being. Moreover, this enables the patient to be

[1] European Parliament Heart Group (EHN) (2017) Cardiovascular Disease Statistics. http://www.ehnheart.org/cdv-statistics.html (March 14, 2019).

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more proactive in heath management, and allows the healthcare providers to make more informed decisions on the basis of real-time data [5].

Many mobile platforms currently support software enabling self-management of cardiovascular disease and capable of collecting cardiovascular data [2]. However, cardiovascular disease most commonly affects older adults, and these individuals have the greatest barriers to mobile healthcare solutions [6]. Hence more engaging self-care solutions that avoid mobile devices should be designed in order to provide the necessary level of support for patients of different ages thus creating a significant behavioral change in population.

Along with this new proactive paradigm for personal healthcare, in [7] we have recently proposed an intelligent monitoring system based on a smart mirror for contact-less estimation of main cardiovascular parameters as well as for the prediction of cardiovascular disease. The underlying idea is to allow the patient to monitor his cardiac status at home, with perfect integration in his daily routine and avoiding the use of additional (mobile) devices. The only effort required to the patient is a very natural action, i.e. looking at himself in front of a mirror for 1 min. The proposed solution is a cheap mirror-based device that is very easy to use, hence it is suitable not only for personal use but also for telemedicine applications.

So far we have tested the efficacy of the smart mirror in terms of accurate measurement of vital signs and reliable assessment of cardiovascular risk. Now, we want to further develop understanding of the benefits and functionalities of our solution that end-users deem as either desirable, undesirable, or inadequate. To this aim, in this paper we present the results of a preliminary study about perception of end-users (health people, cardiopathic patients and caregivers) towards the self-care monitoring process accomplished through the proposed healthcare system.

2 Related Works

The study of the users' needs and perceptions is fundamental to understand their willingness to accept or reject a new technology. The factors that could affect the user acceptance of a new technology have been detected and formalized in several models and frameworks [8], such as the Technology Acceptance Model (TAM) [9], or its evolution the Unified Theory of Acceptance and Use of Technology (UTAUT) [10], that have been widely used in a variety of contexts.

In the healthcare field, more than in others, the users' acceptance and trust of the new technologies is of primary importance. We need to take into account the human characteristics and the social background to avoid a mismatch between the users' expectations and the services available [11].

Several works focus on the users' perception of the new technologies in healthcare. Electronic medical records (EMR) systems have been recently adopted in different part of the world. Interest of the researchers has been the study of opinion by both the practitioners and the patients [12–16].

The users' concerns about security and privacy related to healthcare services affect their risk perception and attitudes toward using IoT-based medical devices

[17,18]. Particularly in [19] the authors focus on users' perception of biometric authentication technologies.

Safety and acceptability are critical issues when people interact with robots in healthcare [20]. Kim et al. compare the users' reactions to different kind of robotic arms and fingers' touch, whilst Ahn et al. gathered young people's perceptions about healthcare service robots for old people [21]. Pal et al. propose a theoretical framework to detect the core factors affecting the elderly users' acceptance of smart home services for healthcare [11]. They conducted an empirical evaluation across four Asian countries to test the framework. Agrell et al. focused on patients' perceptions of home telecare [22]. Febriani et al. designed a smart health chair for car driver's seat, that is able to monitor health vital signs. In their study they analyze the usability and the user satisfaction in interacting with the smart health chair [23].

Health care administrators look at technological innovative solutions to improve the servic quality. Several works discuss the acceptance of information technology in the context of Health Information Management (HIM) [24–26].

Mobile health (mHealth) services are a new frontier for tele-medicine. Zhang et al. investigate the factors that influence individuals' acceptance of mHealth services [27]. Similarly Velez et al. propose a mobile health application for Rural Ghanaian Midwives and study its users' acceptance [28]. Elloumi et al. studied patient and caregiver's perception regarding pervasive cardiac healthcare technology [29].

All the above mentioned works show that a critical issue in designing new healthcare solutions is to assess their acceptability relying on the users' perceptions towards benefits and risks. For this reason, once developed a first prototype of our self-care system [7] we tried to analyze the end-users' attitude and perceptions about the innovative monitoring process introduced by the proposed solution. The rest of the paper is devoted to briefly describe the developed self-care system and to present the results of our study about end-user perceptions.

3 The Proposed Self-care Monitoring System

The proposed self-care system is an intelligent mirror designed to detect some vital parameters without the use of contact sensors [30]. The mirror is equipped with a camera that captures the video frames of the patient who is looking at himself in the mirror. Each frame is processed in real time to extract the remote photoplethysmography signal [31] that measures the change of cardiovascular tissue coming from some regions of the face, in our case the forehead. In fact, the impulse of cardio-vascular wave that flows through the body periodically, stretches the vessel walls, with consequent fluctuations in blood volume. These fluctuations modulate the absorbency of light passing through a given volume of tissue, so it is possible to evaluate the variation of light during a normal cardiac cycle. These changes originate a waveform that resembles the changes in the pulsatile arterial blood in the tissue [32]. Hence by processing the photoplethysmographic signal we can estimate values of cardio-vascular parameters, namely heart rate, breathing rate, and blood oxygen saturation.

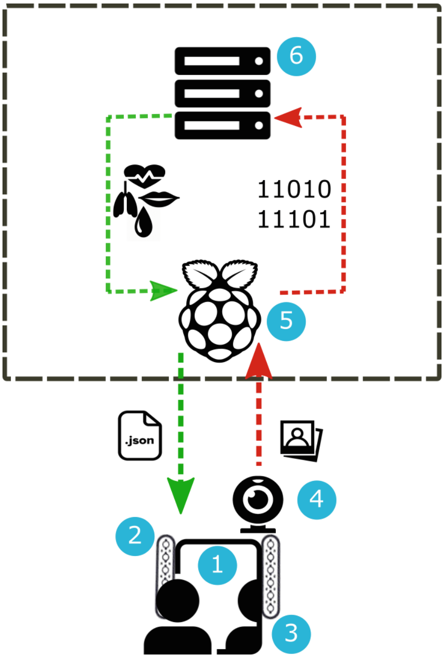

Fig. 1. Hardware architecture.

Our solution differs from other existing contact-less solutions to monitor vital parameters since it integrates a decision-making component that supports medical diagnosis of cardiovascular disease. This component is based on fuzzy IF-THEN rules that were defined with the help of a physician. Starting from these rules the system is able to infer a level of cardiovascular risk starting from the vital parameters acquired by the smart mirror [33]. The output of the fuzzy rule-based system represents an immediate feedback for the patient about his health status, as well as valid support for clinicians in the diagnosis of possible cardiovascular diseases.

Moreover, the use of the device to monitor vital parameters every day enables the collection of a large amount of data about the health status of patients. These data can be checked by the physician who can analyze the accumulated information in a timely manner and provide additional feedback.

3.1 HW Architecture

The device has been designed to be low-cost, immediate to use and easy to be integrated in any home environment. It includes few low-cost basic hardware components (Fig. 1). It is made of a see-through mirror ① with a 12”12” 3 mm thick acrylic film that is partially reflective and partially transparent. The peculiarity of this mirror is that the light can pass equally in both directions, however when one side of the mirror is brightly lit and the other one is kept dark, the darker side becomes difficult to see from the brightly lit side because it is masked by the much brighter reflection of the lit side. Behind the mirror is a monitor that allows users to display information. An illuminated environment ensures a higher quality in the process of detection of vital parameters. To improve the lighting conditions in the environment two strips of LED lights ② ③ have been integrated into the sides of the frame. Each strip includes 18 LED lights having these characteristics: 12 V, 6.0 W, 0.5 A and 120 beam angle. A HD camera ④ is assembled with the see-through mirror to record high-quality video frames. We used the Microsoft LifeCam (3.44" length, 1.57" width) provided with autofocus. A HD 1080p sensor enables acquisition of high quality images. The system is composed of a client/server architecture. The client is a Raspberry pi board ⑤ with CPU Quad Core 1.2 GHz Broadcom BCM2837 64bit, 4 USB ports, 1 GB RAM, Micro SD for the boot of the operating system and data storage. In the current prototypical version of the system, the server ⑥ is a desktop computer equipped with CPU Intel(R) Core(TM) i5–5200 2.20 GHz 64 bit, 4 GB RAM and 500 GB hard disk.

3.2 SW Architecture

The proposed system includes a front-end module that manages the graphical interface and the user-system interaction, and a back-end that processes data coming from the front-end and outputs the results.

The front-end was developed using the engine template Jinja2 that allows creation of HTML or XML files that are sent to the client via HTTP. Using the scripting languages we capture the video frames from the camera and compose the POST request to send data to the Web Service. The Web Service provides the result in JSON format.

The back-end is a Web Service implemented in Flask which is a micro web framework compatible with Python 3.6. Flask is based on the toolkit Werkzeug and the template engine Jinja2, both based on the BSD (Berkeley Software Distribution) open source license. The tool Werkzeug provides several utilities for WSGI (Web Server Gateway Interface) applications and a transmission protocol that establishes and describes communications between servers and web applications. The Client/Server communication is developed using the Ajax scripting language that, combined with the HTML language, enables the exchange of data in background between the browser and the Web Service.

3.3 Application Scenarios

The proposed mirror-based system is intended to be used in the field of personal healthcare (Fig. 2). It was designed as smart device to be installed mainly in a home environment, especially in rooms that are typically equipped with a mirror (bathroom, living room, bedroom). A possible scenario in home environment is the following. Emma is a middle-age lady who is affected by hypertension. For

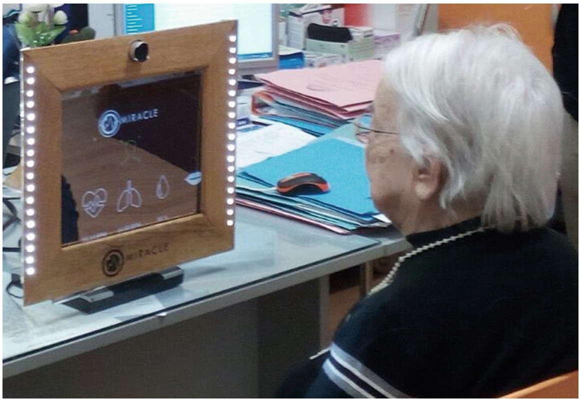

Fig. 2. Application scenario of the proposed healthcare device

this reason she needs to monitor her vital parameters regularly. Every morning, once woken up, she goes to the bathroom to carry out daily actions such as brushing her teeth or combing her hair. While making these natural actions Emma can monitor her vital signs by just looking at herself in the mirror, with no need of additional devices. The possibility to check the personal health status through a simple gesture like looking at oneself in a mirror is especially comfortable for elderly people who may have difficulty to self-monitor their vital parameters through the use of contact devices such as the pulse oximeter, or through mobile devices such as smartphones.

The proposed smart mirror could be well employed in public environments such as pharmacies where other monitoring and prevention services such as weight control are frequently offered. Using the smart mirror every customer entering in the pharmacy could easily and quickly check his health status by looking in the mirror, with no need of any contact device.

4 Evaluating End-User Perception

In this section we report the results of a preliminary study on end-user perception about the developed system. Our focus was primarily in identifying the concerns and attitudes that patients of different ages might have of the concept, as well as exploring potential barriers to acceptance, such as different computer skills and technology awareness. Broadly, the aim of the study is to generate useful feedback for the subsequent deployment of the system.

We defined six main research questions about the factors that could affect the users' acceptance of a our new healthcare technology:

A) What are the social and demographic factors that influence the user's acceptance?
B) Do users perceive the benefits of the self-care monitoring system?

C) Do users see any risk or privacy violation in using the system?
D) Is the system easy to use?
E) Are the users willing to actually employ the system?
F) Do users find the system really innovative?

These points were detailed in a questionnaire that was submitted to each participant at the end of the test session. In each test we used the smart mirror to detect the vital parameters (heart rate, breath rate and blood oxygen saturation) while the subject was sitting in front of the mirror for 1 min. Each subject was required to mirror himself, resting in state of spontaneous breathing. Besides collecting the answers to the submitted questions after test, we also collected general information about the overall reaction and feeling of each user. To this aim the conductor who supported the users during the test took notes on the opinions expressed by some users.

4.1 Social and Demographic Factors

The study involved 30 users, including 21 males and 9 females. The prevalence of male subjects is justified by the fact that, according to different studies [34,35] men are more likely to be at risk for heart attack much earlier in life than women. The sample covered different age groups: young, adult, middle-aged and elderly participants were involved in the study, with ages ranging from 21 to 81 years old. The level of education varied according to the age, but most of the users (27/30) had a high education level and some of them (21/30) were graduate or undergraduate students. Beside the demographic factors, we collected information about the lifestyle (smoke, alcohol, sport) of users in order to find possible correlations between the attention to health and the positive perception towards the self-care process. We observe that most of the subjects lead a healthy lifestyle: 25/30 do not smoke, 24/30 do not drink or moderately drink and 18/30 practice sport. Furthermore, we wanted to evaluate whether subjects with cardiovascular problems, or with cardiac problems in their family history, are more sensitive to adopt the self-care monitoring system. Few participants (7/30) had cardiovascular problems, whilst half of the sample (15/30) had at least one relative who suffered from it. It is interesting to note that participants were not always able to discover if they had a history of cardiac conditions in their family or they did not seek for such information. Table 1 summarizes the distribution of social and demographic factors among the considered sample.

4.2 Benefits

To evaluate the users' perception about the benefits that the self-care system could bring in the all day life, we considered the following three questions:

q-b1 *Do you think that using this system can lead to a reduction in health care costs?*
q-b2 *In your opinion, does the use of this system strengthen the concept of prevention?*

Table 1. Social and demographic factors

Factors		Frequency
Gender	Male	21
	Female	9
Age	21–30	15
	31–40	5
	41–60	8
	61+	2
Education	Primary school	1
	Secondary school	2
	High school	6
	University	14
	Ph.D	7
Smoke	No	25
	Less than 5 time per day	2
	Between 5 and 10 time per day	0
	More than 10 time per day	3
Drink alchool	No	12
	One per week	12
	Twice per week	6
	More than 4 time per week	0
Practice sport	No	12
	Less than 3 times per week	8
	3 times per week	7
	More than 3 time per week	3
Cardiovascular Problems	Yes	7
	No	23
Family history Cardiac problems	Yes	15
	No	15

q-b3 *Do you feel that monitoring your state of health on day-to-day can bring benefits?*

When asked these questions, the majority of patients (28/30) felt that the technology could lead to a reduction in healthcare costs because the daily health monitoring could help the prevention of cardiovascular diseases (29/30) and as a consequence could improve their well-being (28/30). These findings are illustrated in Fig. 3. It is clear that almost all the users perceive the benefits of using the self-care system in terms of all the three research variables, i.e. health cost reduction, prevention increasing and daily monitoring.

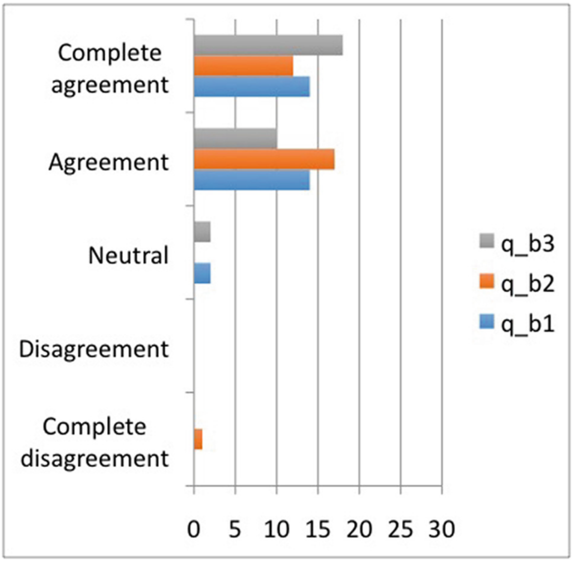

Fig. 3. Distribution of the users' answers to questions related to benefits.

We further analyzed these results in terms of age and gender of the users. We observed that the majority of the male subjects (15/21) perceives the use of the monitoring system as a benefit, but they do not completely agree with the questions. Actually 2 male subjects gave a neutral answer to question q-b1, thus showing some doubts about the possibility to reduce healthcare costs. Actually they were all young men who had never had serious personal healthcare problems and hence they probably were not able to fully appreciate the economic advantage of using a self-care system with respect to standard checkup procedures. Arguably for the same reason, 2 young male subjects expressed a neutral answer to question q-b3. Conversely, the female subjects gave all agreements answers thus showing to appreciate the benefits of a self-care monitoring solution. Only one middle-age female subject was in complete disagreement on question q-b2. This could be probably due to misunderstanding of the question.

On the overall, these results demonstrate an open-minded and positive attitude to the self-care concept. This is supported by the following comments drawn from some transcripts during the test:

"I don't have much time for regular checkups. Sometimes getting a doctor's appointment is very difficult. If you can monitor your parameters at home that would be great."

"I suffer from cardiovascular diseases and I am forced to check my parameters every day through the pulse oximeter, but this brings me pain in my finger. It would be great to have a device that measures my values without hurting or touching me."

4.3 Risks and Privacy

Another objective of this study is to understand the perceived security when using the medical device. Two main topics were identified, privacy violation and risk perception. On the basis of these topics, the following questions were formulated:

q-r1 *Do you think that the use of the system could affect your privacy?*
q-r2 *Do you perceive the use of the system as risky?*
q-r3 *Do you think that the automatic forwarding of your vital parameters to your doctor may involve risks or privacy violation?*

The distribution of collected answers is shown in Fig. 4. As it can be seen, most of the examined subjects consider the self-care system to be fairly safe, hence they do not think that it could be risky in terms of privacy (agreement answers to q-r1 were 17/30). However, it is worth to note that many neutral answers were received, demonstrating that most users were in doubt about the guarantee of privacy. In particular, during the real-time tests we observed that the web camera integrated into the mirror gave rise to a number of concerns, such as:

"Will the web-cam record my video continuously?".
"Is it possible that someone uses the cam for spying me?".
"Who ensure me that the webcam data would not be sent to unauthorized parties?"

Conversely, almost all participants did not see any risk in using the system (complete disagreement answers to q-r2 were 26/30). In spite of that, some doubts about the system were collected during the test:

"You should not exclusively rely on the output of the software".
"Wrong results could panic the patients."
"An automatic monitoring system could lead to a self medication, eliminating the benefits of prevention. Automatic sending of data to the physician could avoid this risk."

Finally, the totality of the patients thought that the automatic sending of the data to their physician does not involve risks (disagreement answers to q-r3 were 30/30). In fact, some participants highlighted the following advantages:

"Great! My doctor will immediately control my state of health."
"I will be able to avoid long queues in the waiting room."

Finally, from the analysis of age and gender, we observed that surprisingly, male adults trust more in the system than male younger subjects.

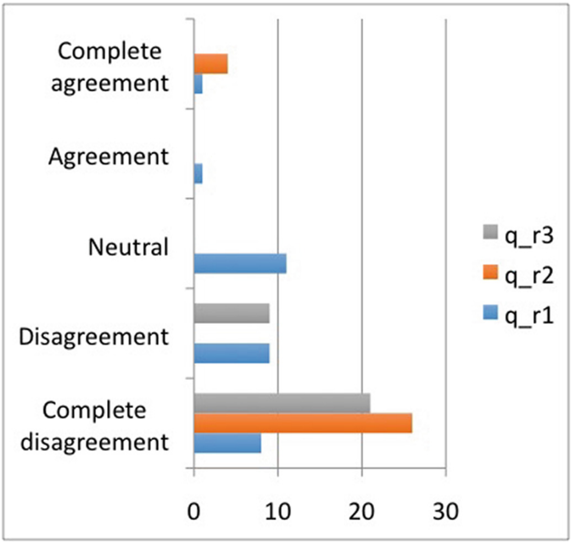

Fig. 4. Distribution of the users' answers to questions related to risks.

4.4 Usability

To evaluate how much the system is ease-of-use, these questions were formulated:

q-u1 *Did you find the interaction with the system easy to use?*
q-u2 *Do you positively rate your experience with the monitoring system?*
q-u3 *Did you find the interaction with the system comfortable and not invasive?*

The results illustrated in Fig. 5 clearly show that almost all users consider the system easy to use. Actually, the majority of the subjects (26/30) provided agreement answers to question q-u1. Users also expressed their opinion on the use of the device and many of them stated that they found the system very easy to use. During the tests we witnessed that the participants easily followed the given instructions and there were no problems during the measurement phase. Only four subjects evaluated difficult the use of the system, but this was due to the fact that during the test session a finger pulsoximeter was used to acuire standard values to be compared to the values measured by the mirror-based system. The pulsoximeter was wrongly considered as a part of the monitoring system, and therefore the whole system was considered unconfortable. Only after compiling the questionnaire these subjects discovered that the pulsoximeter was used only for comparison.

The overall user experience with the system was positive for almost all the participants. Indeed (26/30) subjects gave agreement answers to question q-u2.

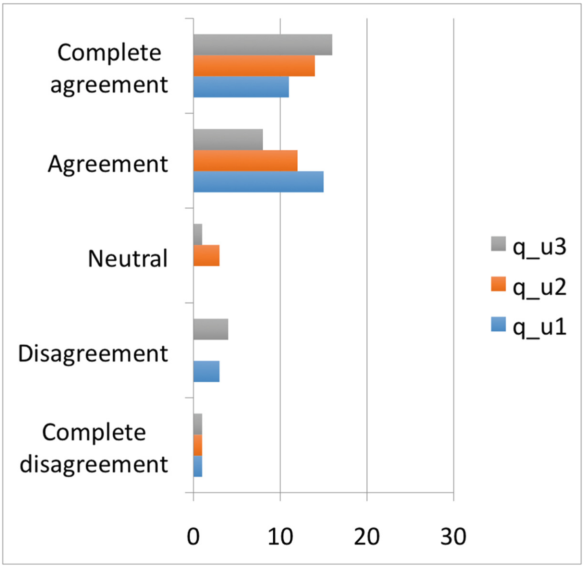

Fig. 5. Distribution of the users' answers to questions related to usability.

Finally, almost all the users (24/30) declared that they found the system comfortable by giving agreement answer to question q-u3. Some of them were even surprised by the speed with which the system returns the measured parameters. Their main comments were the following:

"I thought it would take more time to detect my vital signs."
"Already finished! I thought it would take longer!"

Moreover, as it could be expected, younger subjects, and those with higher education were more confident in using the new technology than the others.

4.5 Acceptance

Finally, we evaluated how much users would be willing to adopt the system at home and also how much they would be willing to spend for such a device. To this aim, the following questions were submitted:

q-a1 *Would you adopt the self-care system in your home environment?* [YES/NO]
q-a2 *How much would you be willing to spend on this device?* [less than 400€, 400€, more than 400€]

We estimated 400€ as reference price taking into account both the cost of HW equipment (see-through mirror, monitor, HD camera, strips of LED lights and Raspberry pi board) and the cost of the know-how for software development and engineering of the entire system.

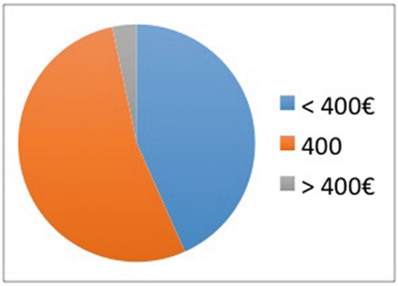

Fig. 6. Distribution of answers to question q-a2.

All the 30 participants answered YES to question q-a1 thus stating a global willing to adopt the system in home environment. Moreover almost half of participants (16/30) consider 400€ to be an appropriate price for the system. The remaining (13/30) subjects would spend less and only (1/30) subjects would be willing to spend more than 400€, as shown in Fig. 6.

4.6 Innovation

The final research variable of our study was the innovation of the system perceived by users. A single direct question was submitted in this case, namely: *Do you think that the mirror-based system is a really innovative solution?*

All the subjects answered positively to this questions, since they were all impressed by the novelty of the proposed monitoring technology. Actually during the tests many participant were amazed by the mirror-based device. Even if most of the users usually interact with electronic devices, they could not conceive how a simple mirror could evaluate vital signs without any contact with the skin. All the users were very surprised about the potential of the mirror-based device. Moreover, at the end of the test, many users claimed to be happy to have discovered that there was a new way of measuring parameters, which they did not know at all before.

5 Discussion

Overall, participants in this study showed a positive attitude toward the use of the new self-care monitoring process. Figure 7 summarizes the average perception of users in regards to the three main factors (benefits, risk and usability) expressed as an average agreement score given for each factor. To compute the average agreement score, we assigned a score to each answer as follows:

– Complete Agreement: 5
– Agreement: 4

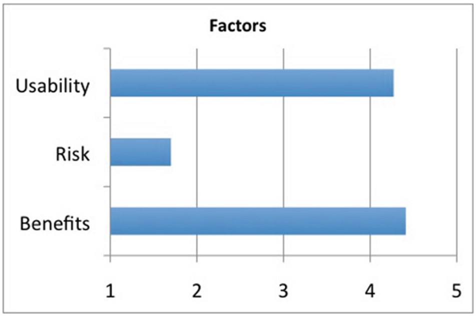

Fig. 7. Averaged perception of users about the main considered factors.

– Neutral: 3
– Disagreement: 2
– Complete Disagreement: 1

It can be seen that a high score was achieved in regards to the potential benefits of the self-care monitoring process. In general positive responses were related to the benefits of continuous, real-time monitoring of a range of parameters related to health condition and the possibility to receive quick feedback in case of potential problems. As concerns usability, the high average score confirms that the mirror-based solution was correctly designed to be easy-to-use, comfortable and not invasive at all. Users see in the mirror an object of daily use, and therefore they find very natural to interact with the mirror-based monitoring device.

A low score was obtained for the negative factor of risks, still indicating an overall positive perception by users'. Actually only some users expressed doubts related to trust and privacy. As concerns the trust, users were immediately convinced about the reliability of the system since the measurements made by the device were comparable to the measurements of the pulse-oximeter used during tests. However they trusted less the response of the intelligent component of the system that suggests a level of cardio-vascular disease according to the estimated parameters. Indeed some users were not completely aware about the decision-support nature of the system that is obviously intended only as a support to the clinician. By no means it is intended to substitute the final decision of the medical expert. Furthermore, aspects of risk or lack of privacy were highlighted by some users for the presence of the web cam and the internet connection. However, most users were not particularly concerned by these aspects since they were aware that these issues are indispensable in any smart connected device.

6 Conclusions

Proactive healthcare systems are aimed to provide users with healthcare solutions to be used directly at home. In this work we have presented a study about end-users' perception toward an innovative solution specifically designed for proactive monitoring of the cardiac status. It is a mirror-based device capable to measure vital parameters in a contact-less fashion. The results of this study showed that there is a general positive feeling towards our self-care monitoring solution, both among young and old people. Despite the encouraging positive results, a deeper analysis should be carried out in order to better explore all the factors that may hamper the acceptance of the self-care monitoring process introduced by the smart mirror. Further work is in progress to collect more data about users' perception so as to provide a solid groundwork describing relationships that people tend to develop with our technology. This will be fundamental to foresee the potential success of our new solution before its actual adoption. To conclude, we believe that this work may also contribute to spread and reinforce the idea of a proactive healthcare model representing patients as being more actively involved in the managing of their healthcare.

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References

1. Cook, S., Togni, M., Schaub, M.C., Wenaweser, P., Hess, O.M.: High heart rate: a cardiovascular risk factor? Eur. Heart J. **27**(20), 2387–2393 (2006)
2. Lupton, D.: The digitally engaged patient: self-monitoring and self-care in the digital health era. Socl Theory Health **11**(3), 256–270 (2013)
3. Swan, M.: Health 2050: the realization of personalized medicine through crowdsourcing, the quantified self, and the participatory biocitizen. J. Person. Med. **2**(3), 93–118 (2012)
4. Diaz, M., Ferrer, M.A., Impedovo, D., Pirlo, G., Vessio, G.: Dynamically enhanced static handwriting representation for Parkinson's disease detection. Pattern Recogn. Lett. **128**, 204–210 (2019)
5. Margiotta, N., Avitabile, G., Coviello, G.: A wearable wireless system for gait analysis for early diagnosis of Alzheimer and Parkinson disease. In: 2016 5th International Conference on Electronic Devices, Systems and Applications (ICEDSA), December 2016, pp. 1–4 (2016)
6. Searcy, R.P., et al.: Mobile health technologies for older adults with cardiovascular disease: current evidence and future directions. Current Geriatrics reports, pp. 1–12 (2019)
7. Casalino, G., Castellano, G., Pasquadibisceglie, V., Zaza, G.: Contact-less real-time monitoring of cardiovascular risk using video imaging and fuzzy inference rules. Information **10**(1), 9 (2019)
8. Taherdoost, H.: A review of technology acceptance and adoption models and theories. Procedia Manuf. **22**, 960–967 (2018)
9. Davis, F.D.: User acceptance of information technology: system characteristics, user perceptions and behavioral impacts. Int. J. Man Mach. Stud. **38**(3), 475–487 (1993)
10. Venkatesh, V., Morris, M.G., Davis, G.B., Davis, F.D.: User acceptance of information technology: toward a unified view. MIS Q. **27**, 425–478 (2003)

11. Pal, D., Funilkul, S., Charoenkitkarn, N., Kanthamanon, P.: Internet-of-Things and smart homes for elderly healthcare: an end user perspective. IEEE Access **6**, 10 483–10 496 (2018)
12. Handy, J., Hunter, I., Whiddett, R.: User acceptance of inter-organizational electronic medical records. Health Inform. J. **7**(2), 103–107 (2001)
13. dos Santos, E.S., Martins, H.G.: Usability and impact of electronic health records for primary care units in portugal. In: 6th Iberian Conference on Information Systems and Technologies (CISTI 2011), June 2011, pp. 1–3 (2011)
14. Vathanophas, V., Pacharapha, T.: Information technology acceptance in healthcare service: the study of Electronic Medical Record (EMR) in Thailand, pp. 1–5. IEEE (2010)
15. Scheepers, R., Scheepers, H., Ngwenyama, O.K.: Contextual influences on user satisfaction with mobile computing: findings from two healthcare organizations. Eur. J. Inf. Syst. **15**(3), 261–268 (2006)
16. Weeger, A., Gewald, H.: Acceptance and use of electronic medical records: an exploratory study of hospital physicians' salient beliefs about hit systems. Health Syst. **4**(1), 64–81 (2015)
17. Alraja, M.N., Farooque, M.M.J., Khashab, B.: The effect of security, privacy, familiarity and trust on users' attitudes towards the use of iot-based healthcare: the mediation role of riskperception. IEEE Access **7**, 111341–111354 (2019)
18. Wilkowska, W., Ziefle, M.: Perception of privacy and security for acceptance of e-health technologies: exploratory analysis for diverse user groups. In: 2011 5th International Conference on Pervasive Computing Technologies for Healthcare (PervasiveHealth) and Workshops, pp. 593–600. IEEE (2011)
19. Rodrigues, P., Santos, H.: Health users' perception of biometric authentication technologies. In: Proceedings of the 26th IEEE International Symposium on Computer-Based Medical Systems, pp. 320–325. IEEE (2013)
20. Kim, D.H., et al.: User perceptions of soft robot arms and fingers for healthcare. In: 2016 25th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN), pp. 1150–1155. IEEE (2016)
21. Ahn, H.S., Lee, M.H., Broadbent, E., MacDonald, B.A.: Gathering healthcare service robot requirements from young people's perceptions of an older care robot. In: 2017 First IEEE International Conference on Robotic Computing (IRC), pp. 22–27. IEEE (2017)
22. Agrell, H., Dahlberg, S., Jerant, A.F.: Patients' perceptions regarding home telecare. Telemed. J. e-Health **6**(4), 409–415 (2000)
23. Febriani, R., Wuryandari, A.I., Mardiono, T.: Design interaction of smart health chair approach the usability aspect on shesop health care. In: 2015 4th International Conference on Interactive Digital Media (ICIDM), December 2015, pp. 1–6 (2015)
24. Abdekhoda, M., Ahmadi, M., Dehnad, A., Hosseini, A.: Information technology acceptance in health information management. Methods Inf. Med. **53**(01), 14–20 (2014)
25. Rodger, J.A., Pendharkar, P.C., Paper, D.J.: End-user perceptions of quality and information technology in health care. J. High Technol. Manag. Res. **7**(2), 133–147 (1996)
26. Malato, L.A., Kim, S.: End-user perceptions of a computerized medication system: is there resistance to change? J. Health Hum. Serv. Adm. **27**(1), 34–55 (2004)
27. Zhang, X., Han, X., Dang, Y., Meng, F., Guo, X., Lin, J.: User acceptance of mobile health services from users' perspectives: the tole of self-efficacy and response-efficacy in technology acceptance. Inform. Health Soc. Care **42**(2), 194–206 (2017)

28. Vélez, O., Okyere, P.B., Kanter, A.S., Bakken, S.: A usability study of a mobile health application for rural Ghanaian midwives. J. Midwifery Womens Health **59**(2), 184–191 (2014)
29. Dhukaram, A.V., Baber, C., Elloumi, L., van Beijnum, B.-J., De Stefanis, P.: End-user perception towards pervasive cardiac healthcare services: benefits, acceptance, adoption, risks, security, privacy and trust. In: 2011 5th International Conference on Pervasive Computing Technologies for Healthcare (PervasiveHealth) and Workshops, pp. 478–484. IEEE (2011)
30. Pasquadibisceglie, V., Zaza, G., Castellano, G.: A personal health care system for contact-less estimation of cardiovascular parameters. In: 2018 AEIT International Annual Conference, pp. 1–6. IEEE (2018)
31. Challoner, A.: Photoelectric plethysmography for estimating cutaneous blood flow. Non-invasive Physiol. Meas. **1**, 125–151 (1979)
32. Allen, J.: Photoplethysmography and its application in clinical physiological measurement. Physiol. Meas. **28**(3), R1 (2007)
33. Casalino, G., Castellano, G., Castiello, C., Pasquadibisceglie, V., Zaza, G.: A fuzzy rule-based decision support system for cardiovascular risk assessment. In: Fullér, R., Giove, S., Masulli, F. (eds.) WILF 2018. LNCS (LNAI), vol. 11291, pp. 97–108. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-12544-8_8
34. Weidner, G.: Why do men get more heart disease than women? an international perspective. J. Am. Coll. Health **48**(6), 291–294 (2000)
35. Schwarzer, R., Rieckmann, N.: Social support, cardiovascular disease, and mortality. In: Heart Disease: Environment, Stress, and Gender. NATO Science Series, Series I: Life and Behavioural Sciences, vol. 327, pp. 185–197 (2002)