Internet of Things Technology for Remote Healthcare – A Pilot Study

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Abstract

One of the latest trends in health informatics is Internet of Things (IoT). IoT consists of various types of technical objects connected to Internet and/or connected to each other, cooperating to reach a common goal. This pilot study explores how chronic patients, potential patients and healthcare personnel (n=100) perceive sensors and implanted sensors as two examples of IoT in remote healthcare. Data was collected through an acceptability questionnaire based on the Unified Theory of Acceptance and Use of Technology (UTAUT) framework using criteria as: performance expectancy; effort expectancy; attitude towards technology; and social influence. The pilot result indicated e.g. a strong acceptance of implants and that external sensors in a treatment requires further work. Differences between men and women were found: acceptance of sensors was preferred by women, and implants by men. In conclusion, IoT could be used to enhance person-centered healthcare, aiming to better engage patients in their treatment, rather than being a passive recipient of a medical intervention.

Keywords:

Biomedical/Health technology assessment, Patient Care Management, Patient Acceptance, Pilot study, Telemedicine, eHealth, Point of Care Technology, Internet of Things.

Introduction

With each passing day, technology takes a step forward and creates a reality of what could previously be thought of as being only a dream. Twenty years ago, it was unique to have a personal computer connected to internet and today 92 % of the Swedish population has access to internet on several devices [1]. Technology is developed together with other factors in society. Some effects are that life expectancy of people grows and higher demands are put on the healthcare system. Health and social care must become more effective as more and elderly people will seek and need care. Remote healthcare is one of the solutions that adapts technology to provide good care [2].

Within Swedish healthcare there is a trend to work more person-centred, similarly to concepts as patient-centred [3] or people-centred [4], in order to include the patient and the whole person in the care process [5, 6].

Patients are supposed to, together with their healthcare staff, come up with a plan that works for them. Rather than being a passive part of the treatment, the patient is included and a partnership is formed [7].

One of the latest trends in health informatics is Internet of Things (IoT). The principal idea with IoT is the presence of objects surrounding us, e.g. mobile phones, sensors and RFID-tags, which through wireless networks cooperates with each other to reach a common goal. A prominent strength with this technology is the effect it will have on the daily lives of people from several different aspects [8]. Technical solutions reach the market and an increasing number is developed with the intent to make healthcare more effective, but how do patients feel regarding these technical solutions? How do they feel about implanting a sensor in their body?

The purpose of this study was to examine the receptiveness of remote healthcare through IoT technology, such as external (or wearable) sensors and implants. Using the Unified Theory of Acceptance and Use of Technology (UTAUT) [9] this study measures the acceptance of current and potential patients regarding a few existing IoT solutions.

Research Questions

In terms of acceptance, which type of IoT technology for remote healthcare do patients and potential patients prefer?

By a set of sub-questions this study examined which of the presented IoT technologies that the respondents would prefer for daily use and if there are any differences in acceptability between different subgroups of the respondents:

- current patients and potential patients?
- healthcare professionals and non-healthcare professionals?
- men and women?

In relation to hypothetical acceptability, we also aimed to examine perceived usability of the presented IoT technology.

Theoretical and Technical Background

Examples of IoT Technology in Remote Healthcare

New technology provides the possibility to solve problems that previously seemed impossible to solve. This study exemplified this to its respondents by highlighting two new IoT solutions for healthcare, an implant and a wearable sensor, both applicable for treatments based on remote healthcare.

The first technology is the iDiab and zPhone technology [10]. The purpose of the solution is to facilitate the life of diabetic patients and to streamline the care process for professionals. In the iDiab article [10] we meet the fictional character Robert who is suffering from diabetes. Robert has had an iDiab sensor implant that continually measures his blood sugar level and informs Robert should the level reach critical amounts advising him to inject insulin. The connected zPhone transmits data to Robert's physician for further evaluation and care planning.

The other technology uses external sensors to facilitate and streamline effectiveness of remote healthcare within an Ambient Assisted Living setting. Also here, two methods are combined: online measurement of blood pressure, pulse and other values of the patient and a Tele Monitoring Service Centre acts as an intermediary for the patient and the caregiver, sending and receiving data to both parts to help streamline the treatment of the patient [2]. Both solutions are currently in a prototype testing stage.

Previous Research

Current research within information systems is focused, amongst other things, towards identifying factors which are crucial for the use of new technologies [11]. Regarding acceptance of new technology this has led to several newly developed measurement models originating from informatics psychology and sociology, where e.g. Technology Acceptance Model (TAM) [12] is frequently used. To measure acceptance of new technology it is also possible to mix theories [9] or to use UTAUT which is an extension of TAM [9, 12, 13]. Also within the area of healthcare these methods are used, but the authors have not found many acceptance studies specifically concerning IoT technologies in healthcare.

In Thailand, a broad study using a UTAUT questionnaire was conducted to identify factors affecting IT systems within healthcare [14]. As one of the central results was facilitation of understanding of how the system could improve users' productivity [14], usability was considered also in this pilot study. Like our study, another Swedish UTAUT study also tries to capture the perceived usefulness of e-services in healthcare, although in an different area; the medical professionals' perceived advantage of an online care and rehabilitation planning tool for stroke patients [15]. Only one UTAUT study regarding acceptance of wearable technologies within healthcare was found [16]. A central finding to reuse in our study was that the user experienced a high value in the following UTAUT criteria: perceived expectancy; effort expectancy; self-efficacy & perceived severity during use [16].

Comparisons of UTAUT with other models for creating questions [9] conclude that UTAUT had a substantial improvement compared to the other models, e.g. TAM, regarding the users' variation in intentions towards the usage of the technology [9].

Methods and Materials

This study was based on the theory of UTAUT as a framework and more explicitly as the method to examine the acceptance of the two different IoT techniques in remote healthcare. Recent studies that apply UTAUT criteria were used as inspiration for the questionnaire [17, 18, 19, 20] We also aimed to examine perceived usability of the presented IoT technology, inspired by Davoody & Hägglund [15].

The questionnaire contained 18 questions, where seven of them regarded acceptance (table 1) and checkbox answers (table 2 and 3) based on four of the UTAUT criteria, interpreted in the following way:

- Performance Expectancy – Measures how the user expects that the technology affects the user's life.
- Effort Expectancy – Measures how hard the user believes the technology will be to use or understand.
- Social Influence – Measures if the user's surroundings affect the user's choices whether to use the technology.
- Attitude Towards Technology – Measures the user's attitude towards the technology.

It also contained eight questions (1-8) about the respondent: age, gender; if care professional; if chronic patient; if remote care recipient; contact frequency with healthcare; about remote care and how it was experienced and two open follow-up questions about the experience of remote care (9)and the preferred treatment (16). The last question (18) regarded the possibility to follow up the answers in an interview. The questionnaire was published 2015-11-29 in the Facebook groups "Dom Kallar Oss Studenter" and "Informatikgruppen Örebro Universitet" as well as on personal timelines to reach as many respondents as possible. It was closed 2015-12-02 when 100 responses were received.

Table 1 – The 18 questions, translated into English

	Questions related to acceptance in the web questionnaire
10	Imagine yourself in the following situation: You have diabetes. How do you think an implant according to the following scenario * would affect your healthcare experience? * Scenario description based on [10]..
11	What do you think of using implants in your body according to the scenario*?
12	What is your general attitude towards having an implant according to the scenario *?
13	Now imagine that you instead of the implant are using a bracelet or a plaster on your body to perform measurements **. How do you think a wearable sensor according to the scenario would affect your healthcare experience? ** Scenario description based on [2].
14	What do you think of using the bracelet or plaster in your treatment according to the scenario **?
15	What is your general attitude towards using external sensors in a treatment according to the scenario **
17	Would you as a patient mind getting treatment only through remote care, provided the treatment is of the same or better quality as the traditional one? Yes, of [timesaving], [improved quality], [less trips to caregiver] reasons. No, [no, prefer traditional healthcare visit]. No opinion. Other.

Respondents

The number of respondents in this pilot study was set to 100, distributed on 46 women and 54 men, with birth years ranging from 1962 to 1996. The average year of birth for respondents was 1989, i.e. the mean respondent was 26 years old. Ten respondents marked that they were suffering from a chronic disease and the respondents who worked within healthcare were 16 in total.

Due to the low number of respondents, the analysis should not be used as a statistical basis, but the results of this pilot study can be viewed as an indication that could lead further research.

Choice of IoT solutions to present as examples

Two examples of IoT technology were presented to the respondents in remote healthcare scenarios in order to make IoT technology easier to relate to. A number of criteria was developed in order to sift out those IoT solutions related to the purpose and field of this study:

- The solution should be based on IoT technology.
- The usage of the solution should be within healthcare.
- The purpose of the solution should be to facilitate the life of patients.
- The purpose of the solution should be to improve the treatment from the perspective of the patients.

We chose an implant technology called iDiab and its connected zPhone [10]. The target disease for the solution is diabetes, which was suitable as it is a widely known disease making the scenarios presented easier to relate to for the respondents. A wearable sensor technology was also chosen, used for measuring pulse, blood pressure, movement and other values, which are sent to healthcare professionals via a Telemonitoring Service Centre [2]. One practical example for each of the technologies was described as support for the survey questions.

Data analysis

Data was analysed using a frequency analysis, meaning that the frequency of how a specific question was answered was summarized in a table to display the share of the responses [21].

Data was separated based on different respondent groups, e.g. age and gender, patients or non-patients. Current health status was important in order to be able to compare the answers of a person with a chronic disease to a person who was not suffering from any chronic disease. People who expressed being experienced in using similar technology were grouped in one group as well as others with a theoretical knowledge of such technology, e.g. healthcare professionals.

In this study, non-patients, i.e. persons not currently engaged in active medical treatment, are called potential patients, as there is a hypothetical potential of becoming a patient in the future, and as such being able to use remote healthcare solutions or IoT technology such as implants or wearable sensors.

Results

In the analysis of this study, the results are connected to the four selected UTAUT criteria to assess the acceptability for the two IoT technologies presented in this study, external sensors and implants. Some important differences found in the results are visualized in six circle diagrams, which are explained below (figure 1-6) and the legends of the labels of the diagrams are presented in table 2 and 3.

Figure 1 – Women and the idea of using implants

As seen in figure 1, which shows the distributed answers for women regarding use of implants, the major part thought of the technology as a generally good idea. A quarter of the total answers leaned towards both that the technology was a good idea and that they would enjoy using it while 19 % answered that the technology was a good idea only. 11 % did not think any of the alternatives would fit their view on implants and chose to answer “none of the alternatives”.

Figure 2 – Men and the idea of using implants

Men, who responded towards using implants in their treatment thought the idea was good, represented 35 % of the distributed answers. Another 22 % thought of the technology as a good idea and would enjoy using it. 17 % of the male respondents thought that all the positive answers fit their view and answered A together with B and C. 14 % however answered none of the alternatives showing that at least a sixth of the respondents among men were unconvinced.

Table 2 – Legend to figure 1 and figure 2.

A	This would improve my treatment experience
B	This would make my life more like one without my illness
C	This would improve my treatment
D	None of the alternatives
E	A together with C
F	A together with B and C
G	B together with C

Figure 3 – Women and the use of wearable sensors.

A 33 % thought of wearable sensors as being a good idea while almost a fifth, 19 %, were unconvinced and chose none of the alternatives. Only 11 % chose a combination of multiple positive answers. 28 % were evenly distributed amongst the options stating that the technology is a good idea and that they would enjoy using the technology.

Figure 4 – Men and the use of wearable sensors

28 % of the men who responded regarding the use of a wearable sensor chose all the positive answers (A together with both B and C). 11 % chose none of the alternatives while 26 % stated they viewed the technology as being a good idea but nothing more.

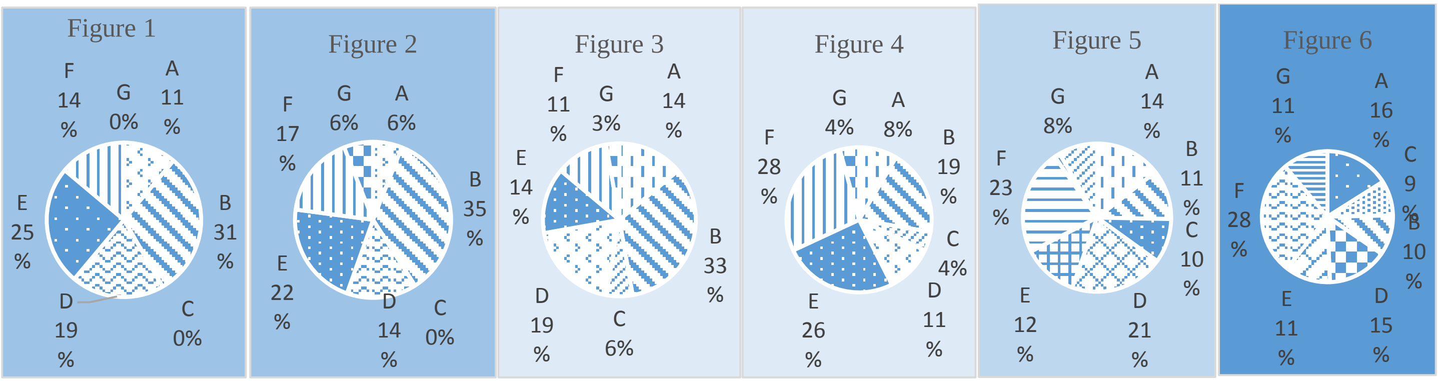

Figure 1-2: women/men & implants. Figure 3-4: women/men & sensors. Figure 5: Sensor treatment. Figure 6: Implant treatment.

Figure 5 – Sensor treatment experience amongst the patients that were not employed in healthcare

A 21 % did not see any of the alternatives fit their expected view of the effect from the IoT treatment. 23 % felt that all of the options reflected their experience with the treatment technology and 79 % felt that it had a positive effect in one way or another.

Figure 6 – Implant treatment experience amongst the patients that were not employed in healthcare

Only 15 % felt that none of the alternatives reflected their view of the effect the treatment hypothetically would have on them. 85 % felt that the technology would have one or another positive effect on their treatment. 28 % felt that all of the positive answers reflect their experience with the technology in use with a treatment.

Table 3 – Legend to figure 3, 4, 5 and 6.

A	I would enjoy using the technology
B	The technology is a good idea
C	People in my environment would like for me to use the technology
D	None of the alternatives
E	A together with B
F	A together with B and C
G	B together with C

Discussion

Data collection method and respondent groups

An open web questionnaire link was distributed in several channels. It provided in a short time 100 responses. The number and type of respondents could correlate to the amount of days the questionnaire was open as well as the forums in which it was published. We closed the questionnaire after reaching 100 responses and luckily the respondents belonged to varying groups which provided possibilities for comparison. There was a 50/50 ratio between female and male respondents as well as respondents who had received remote healthcare previously, healthcare professionals and patients with chronical illnesses albeit smaller groups. For following studies these specified respondent groups could be addressed directly and in larger amounts, rather than focussing solely on some respondent groups, such as e.g. chronically ill patients. Moreover, when using the indications of this pilot study for further research, complimentary interviews should be planned for, to get the possibility to go deeper into the reasons behind the responses, which also could be of interest.

Analysis method and interpretation of the results

The objective of this pilot study was to bring an indication on what type of new IoT technology the respondents would prefer, in terms of acceptance and potential use of the technology.

Some disadvantages with UTAUT are that the effective use of the technology which it examines cannot be visualized (in e.g. percentage), nor is it possible to draw concrete conclusions as UTAUT do not cover usage factors that may affect the user's life situation or work performance [21].

As the respondents never have had the chance to test the technology in person, an interpretation of the criterion performance expectancy was needed. In general, performance expectancy is about what the respondents could expect of the result of using the technology. In this study, the criterion is related to how respondents hypothetically expect that the technology would affect their care experience, treatment and quality of life.

Nevertheless, we consider the method useful when you need an indication of acceptance and potential use of a technology as in this study.

Here, some of the results are further discussed: the chronic patients were more positive towards implants compared to wearable sensors. This could possibly be the result of the wearable sensor being a constant reminder of their health, or the lack thereof, and therefore they preferred the implant. There is also a risk that the sensor could be damaged from daily use and thus the implant is a more viable option for the users who know how it is to live with a disease that requires daily treatment. Such responses, as well as potential differences between men and woman could be further analysed. In this study men and women differed in how they perceived the technologies would change their healthcare experience. Men seemed to favour the wearable sensors while women seemed to prefer the implanted sensor. This could possibly be due to women having experiences with other implants, such as e.g.

contraceptives for birth control, as mentioned in the questionnaire.

The vast part of the respondents expressed a positive view and stance towards using either implants or wearables to extend their current treatment plan. This could be an indication that the general public is ready to embrace a new form of healthcare treatment plan with more focus on enabling the patients to go about their lives in a normal fashion while still being under treatment.

Future work

To further investigate how current patients that undergo remote care treatments would like to use IoT, we recommend further studies to include associations for these persons such as e.g. diabetic associations. Further work could also be based on investigating challenges in deployment of the presented technologies on a broader and wider scale within the healthcare system.

Conclusion

In this pilot study chronically ill patients showed more positive attitudes towards the use of implanted sensors compared to external sensors. Respondents who had previously received remote healthcare also indicated that they could see an improvement with an implant in comparison to wearable sensors. Replies from the potential patient group demonstrated a similar tendency, although the wearable sensor also had a high number of positive replies. The same trend could be seen in the group of healthcare professionals: in general, implants had a positive response rate that was almost twice as high as the number of positive responses for wearable sensors. A majority also felt that the idea of implants was easier to understand and to use compared to the presented alternative. The analysis however showed a difference between men and women: the women indicated a 50 % larger distrust towards the external sensor.

Due to the low number of respondents (N=100) this study should be seen as a pilot study and its result should be viewed as an indication for further research. The results were however interesting and indicate that the respondents find that remote healthcare with presented technologies could be applied to improve person-centered care.

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