User's Perceived Attitudes and Acceptance Towards Wearable Devices in Healthcare

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ABSTRACT

With the coronavirus (COVID-19) pandemic uncovering several structural problems within the German healthcare system, especially within the inpatient sector, rapid improvements were needed to strengthen the preventive industry of the healthcare system. To adequately cover prevention as well as aftercare needs, some telemedical solutions, such as wearables can strongly contribute to the preventive sector. Therefore, this research aims to understand users' perceived attitudes and acceptance towards wearable devices in healthcare. Following the Technology Acceptance Model, the essential factors that influence user acceptance were assessed using an online survey involving 154 participants, students of the Deggendorf Institute of Technology. The results of this survey indicate that among the students' technology acceptance is generally high, participants had a favourable attitude towards digital health technologies, a high perception of usefulness, and a heightened perception of ease of use. Only a minor of the participants have stated that they have certain concerns, mainly regarding data protection. This study however gives very little insight into what elderly people, people in the active workforce, or those suffering from chronic illness think of wearables and digital health as a whole. So further research including this demographic of people is suggested.

Keywords: Acceptance, Healthcare, Users, Wearables.

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1. Background

The coronavirus (COVID-19) pandemic exposed structural problems within the German healthcare system, especially within the inpatient sector. To alleviate the strain on hospitals and medical staff, several measures were implemented. These included recruiting additional personnel, postponing scheduled operations, and converting inpatient facilities into infectious disease or intensive care beds [1]. Hygiene measures were also strengthened, visitor regulations changed, and treatment processes adopted. However, even before the pandemic, the German health system faced challenges such as a shortage of general practitioners, nurses, midwives, and therapists [2].

To address prevention and aftercare needs, telemedical solutions like video consultations were introduced. Senior physicians at the University Medical Centre Hamburg-Eppendorf reported the success of these measures, with 60% considering them successful and 72% acknowledging good patient acceptance [1]. Interdisciplinary collaboration also improved with the help of digital solutions [3]. This suggests that digital tools can ease the burden on both inpatient and outpatient sectors and expand preventive healthcare [4]. Wearables, like smart devices, can track bio information and contribute to preventive healthcare allowing both diagnosed patients and anyone who is concerned with their health to keep track of their health data, medication, and treatments from home [5]. Expanding the preventive sector through digital solutions could also save billions of Euros as estimated by a 2022 study [6].

This research aims to help to understand user's perceived attitudes and acceptance of wearable devices in healthcare. Therefore, the objectives of this research are (i) to learn what wearables are and what purpose they can fulfil in healthcare environments, (ii) to assess users' technology acceptance towards wearable devices as well as what usefulness conditions aid in said technology acceptance, and (iii) to learn about the requirements that may help direct users towards more effective behavioural health, all to broaden future understanding of achieving effective health behaviour.
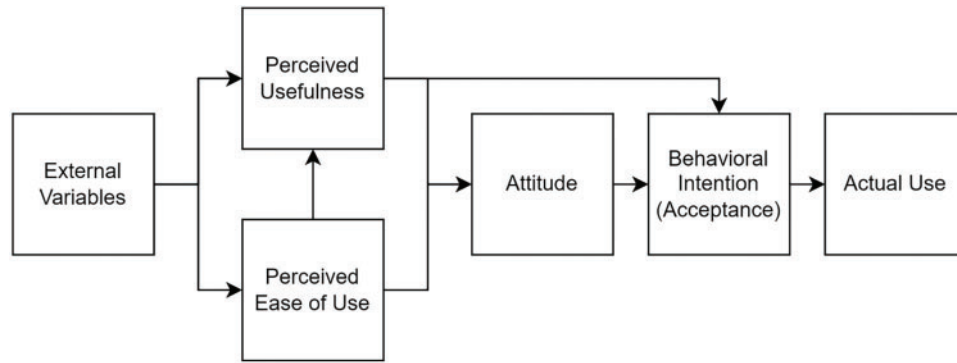
Fig. 1. Technology acceptance model.

2. METHODOLOGY

2.1. Literature Research

To gain knowledge about the medical purpose of wearables, and pulse oximeters specifically, the medical database "PubMed" was used, whereas "Google Scholar" was used to find papers on technology acceptance and user behaviour. For additional information, the websites of the German Health Ministry as well as the German Consumer Direct were considered. The literature research was conducted in both German and English language.

2.2. Hypothesis Development and Research Model

In Fig. 1, the essential factors in the Technology Acceptance Model (TAM) that influence the user acceptance of wearables are identified as *perceived usefulness* and *perceived ease of use* with other external variables such as *subjective impressions, social influence, concerns*, or *attitudes towards digital health* [7].

Perceived ease of use and perceived usefulness are commonly regarded as the two main factors affecting attitude and behavioural intention [8]. Following the definitions of PU and PEOU and Attitude given above, the following hypotheses are to be proposed:

H1.1: Perceived usefulness (PU) has a positive impact on attitude towards using (ATU).

H1.2: Perceived usefulness (PU) has a positive impact on behavioural intention (BI).

H2.1: Perceived ease of use (PEOU) has a positive impact on perceived usefulness (PU).

H2.2: Perceived ease of use (PEOU) has a positive impact on attitude towards use (ATU).

H2.3: Perceived ease of use (PEOU) has a positive impact on behavioural intention (BI).

H3: Attitude towards using (ATU) has a positive impact on behavioural intention (BI).

Social Influence, defined as the impact of family members, friends and generally people whose point of view is seen as worthwhile, also imposes an influence on both PU and PEOU [8]. Therefore, the following hypothesis will be added:

H4.1: Social influence (SI) has a positive impact on perceived usefulness (PU).

H4.2: Social influence (SI) has a positive impact on perceived ease of use (PEOU).

Subjective impressions, such as the experience of joy or comfort while using a technology may strengthen the individual's intent to use a technology again and gain experience. "As a result, the usefulness and easiness of a system perceived by the user may be affected positively" [7], [8]. Considering those findings, the related hypotheses were formed as follows:

H5.1: Subjective impressions (SIM) have a positive impact on perceived usefulness (PU).

H5.2: Subjective impressions (SIM) have a positive impact on perceived ease of use (PEOU).

Concerns, as in anxiety about using technology, may be caused by an individual's fear of making mistakes or losing information due to wrong actions. As concerns increase, the person's perception of the effort required to use the system increases, negatively impacting the PEOU. Additionally, these concerns may interfere with the user experience, negatively impacting PU [8]. Subsequently, the addition of the following hypothesis is to be proposed:

H6.1: Concerns (CON) have a negative impact on perceived usefulness (PU).

H6.2: Concerns (CON) have a negative impact on perceived ease of use (PEOU).

Attitudes towards digital health "are positively related to favorable attitudes or willingness to adopt a technological product." More positive attitudes toward technology, in general, can result in more favorable attitudes toward a new technological product and subsequently greater purchase intention [9]. Therefore, the following hypothesis is proposed:

H7.1: Attitudes towards digital health (ATDH) have a positive impact on attitudes towards using (ATU).

H7.2: Attitudes towards digital health (ATDH) have a positive impact on behavioral intention (BI).

According to all of the above-mentioned hypotheses, Fig. 2 represents the research model for the project [7]–[9].

2.3. Questionnaire

The main instrument of this research is an online survey containing three major parts: demographics, individual health status and TAM according to the research model above.

The questionnaire was divided into eight sections:

A brief demographics part was created in order to gain information on the interviewee's age group, gender and educational level using Likert scale types of questions. This section is followed by an extensive inquiry about the interviewee's personal health status and behaviours, only including yes-or-no questions.
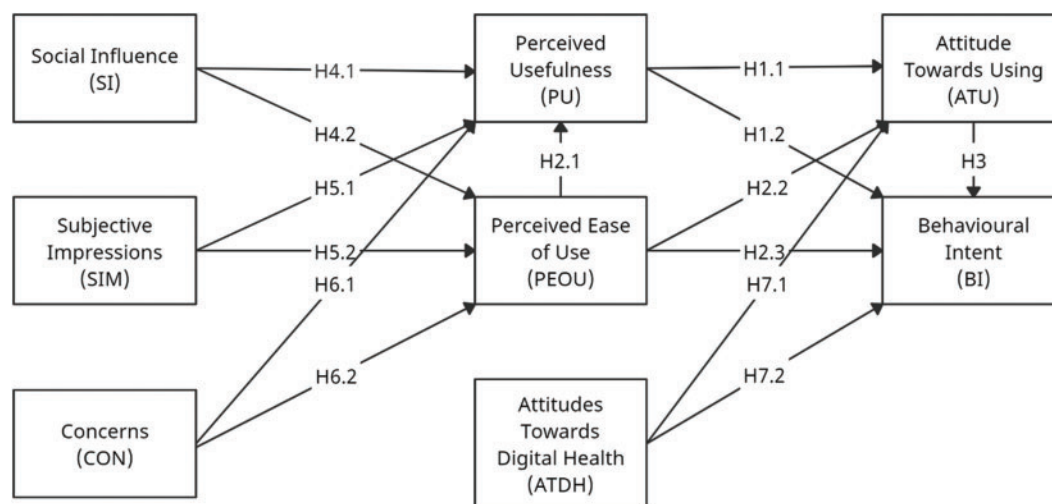
Fig. 2. Research hypothesis model.

As for the actual TAM part of the questionnaire, the variables SI, SIM, CON, PU, PEOU and ATDH were assessed in their own designated sections using a total of thirty questions with a five-point Likert scale such that "1" indicated "Strongly Disagree", "2" indicated "Disagree", "3" indicated "Neutral", "4" indicated "Agree" and "5" indicated "Strongly Agree".

The creation of the questionnaire took several cycles starting with a questions catalogue on a simple MS Excel sheet, that was repeatedly adjusted according to the feedback given by the supervisor of this research. Said catalogue was then put into the online survey tool "soscisurvey.de" which was ultimately used for the creation of the final questionnaire and the survey's distribution.

2.4. Distribution Method

The questionnaire was distributed via email at the campus of the Deggendorf Institute of Technology. With the online tool "soscisurvey.de" a link was created allowing anyone who used that access link to complete the survey. The questionnaire was open for completion from April 10 until April 25, 2022.

On the campus of the Deggendorf Institute of Technology, emails addressed to the entire student body need to undergo an approval process, which took five days, causing the majority of clicks and interviews to be collected on April 15, 2022.

2.5. Eligibility Criteria

When distributing the survey, there was no intended focus on a special demographic, as it is the objective of this research to gain data on technology acceptance across a wide range of the population. That being said, it has to be noted that the survey was distributed at a university, likely increasing the number of younger participants with a level of higher education.

The above-mentioned distribution method caused a total of 293 people to click on the survey. However, this number also includes all cases, in which the browser tab or window was immediately closed again and those who did not continue after reading the introduction. Eliminating those cases reduces the number of interviews started to 206.

Those questionnaires that were completed to the very last item on the very last page are considered eligible, further reducing the number of eligible interviews to 154.

2.6. Data Analysis

The "soscisurvey.de" tool offers a variety of formats to export the collected data to, including options like Comma Separated Values (CSV), Statistical Package for the Social Sciences (SPSS), Structured Query Language (SQL) and several more. Regarding the nature of this research, data evaluation in MS Excel was considered sufficient. The gathered data was exported to an Excel sheet, in which it was analysed, visually represented in graphs and subsequently inserted into the research hypothesis model.

3. RESULTS

With the data collected from 154 participants of the survey, the following results have been created:

3.1. Demographics

There is a slight majority of female participants 51%, whereas male participants made up 48%. Only one participant has stated their gender as diverse making up the last 1%.

The vast majority of participants are rather young, with 92% being in the age range of younger than 35 years. Only a small minority 8% have stated their age range to be above 35 years.

Every participant has at least a high school degree or abitur, college degree, university degree, master's degree, or Ph.D.

3.2. Health Status

The survey has shown that the vast majority of participants lead a rather healthy life. Only the smallest minorities seem to suffer from chronic diseases. According to Table I, most of the participants do not partake in unhealthy behaviours such as smoking or regular alcohol consumption. The only exception to this is the regular consumption of coffee.

TABLE I: Participants' Health Status

Question	Number of participants	
	Yes	**No**
Eats junk food regularly	28% (43)	72% (111)
Consumes alcohol regularly	30% (46)	70% (108)
Drinks coffee regularly	52% (80)	48% (74)
Smokes regularly	8% (12)	92% (142)
Is in the process of quitting smoking	7% (11)	93% (143)
Suffers from COPD	9% (14)	91% (140)
Suffers from hyperthyroidism	3% (4)	97% (150)
Suffers from diabetes mellitus	2% (3)	98% (151)
Suffers from hypertension	2% (3)	98% (151)
Suffers from heart failure	2% (3)	98% (151)

3.3. Attitudes Towards Digital Health

According to the research hypothesis model, hypotheses 7.1 and 7.2 specifically, attitudes towards digital health are supposed to have a positive impact on attitudes towards using a technology and behavioural intent.

The survey has shown that the majority of participants seem to have a positive attitude towards digital health (Fig. 3). Additionally, a significant number of participants expressed willingness to share wearable data with their doctors (Fig. 4), while an overwhelming majority approved the use of wearables in monitoring daily activities (Fig. 5).
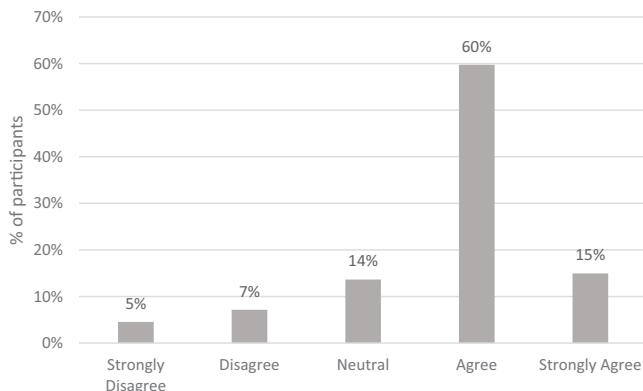

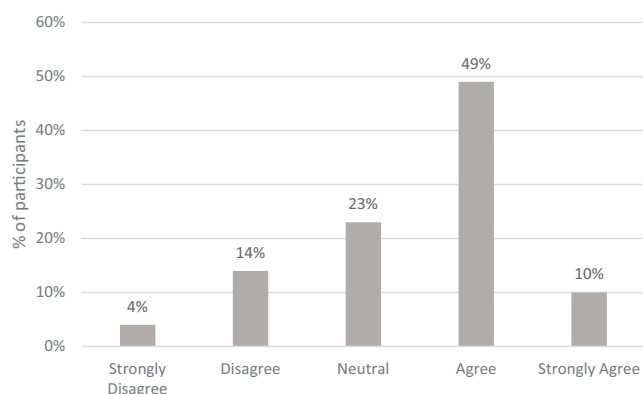Fig. 3. Participants willingness to share wearable data with their doctors.

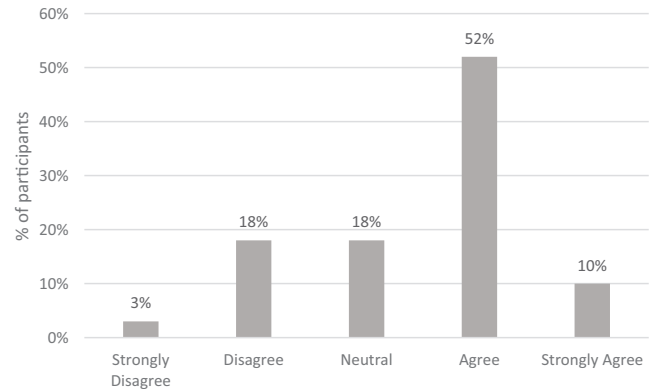Fig. 4. Participants thinking digital health apps will contribute to society's health.

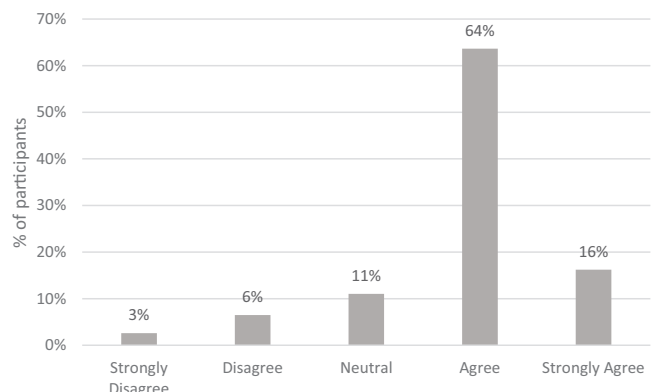Fig. 5. Participants approving of the daily monitoring of one's activity/health.

Fig. 6. Participants thinking that corresponding health apps help monitor progress.

3.4. Perceived Usefulness

The research hypothesis model of this thesis suggests in H1.1 and H1.2 that perceived usefulness has a positive impact on attitude towards using and behavioural intention.

While a small majority still seems to agree with the given statements of the five items of this category, the average rate of approval is not as high as in the section measuring attitudes towards digital health.

The highest rate of approval can be seen in Fig. 6 with few participants disagree with smartphone applications helping to monitor health progress.

The lowest rate of approval however can be seen in Figs. 7 and 8. Only 30% of all 154 participants seem to agree with both given statements.

Wearables can help people live longer in their own homes, but 25% of participants disagree and 3% strongly disagree (Fig. 7).

Fig. 8 shows with the idea that using wearables could help people to get rid of bad habits with 38% of 154 participants disagreeing.

3.5. Perceived Ease of Use

According to the research hypothesis model, perceived ease of use has a positive impact on three variables: perceived usefulness, attitude towards using and behavioural intention.

The survey shows that also in this category, the majority of participants seem to be favourable to the given statements.
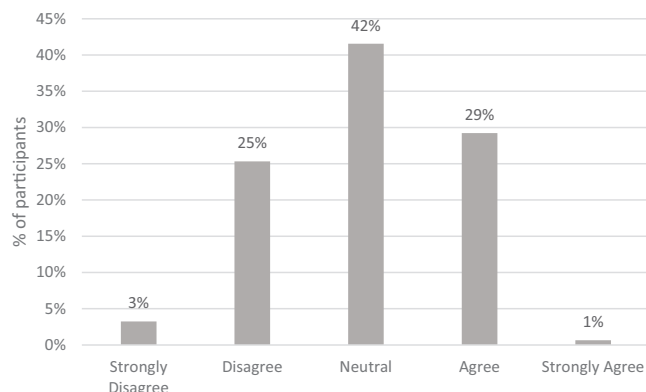
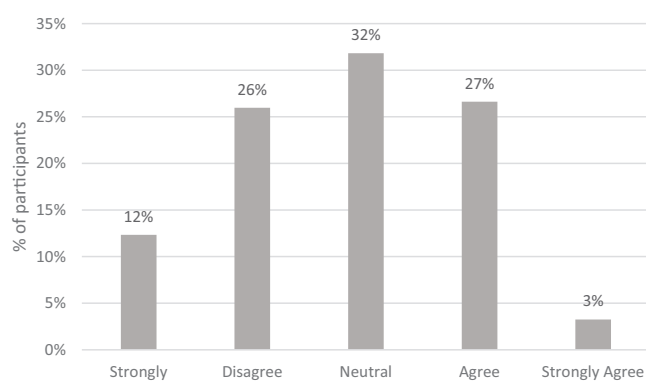Fig. 7. Participants thinking using wearables can let one live at home longer.

Fig. 8. Participants thinking using wearables can help get rid of bad habits.
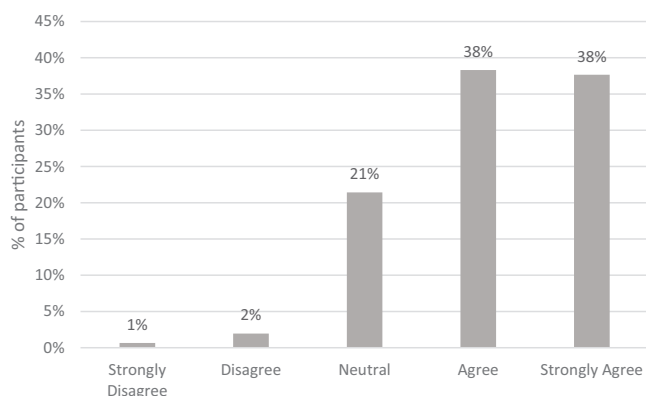

Fig. 9. Participants being able to put on the wearable without help.
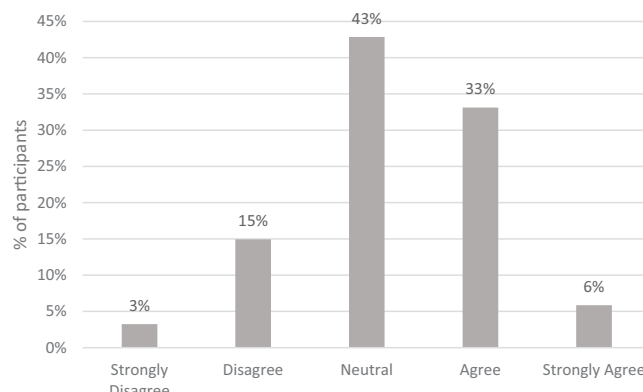

Fig. 10. Participants thinking the battery life of wearables meets expectations.
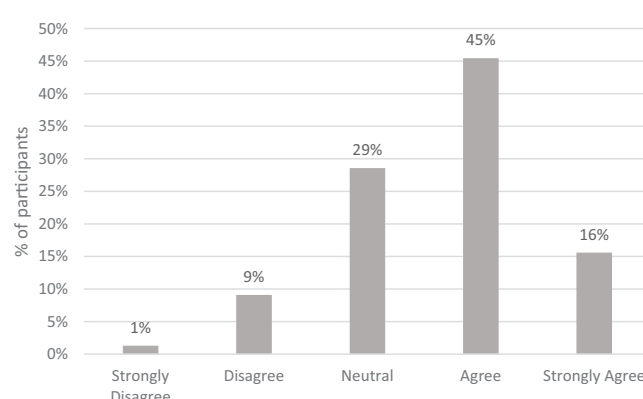
Fig. 11. Participants feeling physically comfortable wearing a wearable device.

Again, beginning with the highest rate of approval, which can be seen in Fig. 9, showing 76% of 154 participants agree that wearables are easy to put on, with only minor disagreeing or strongly disagreeing.

The lowest rate of approval and the highest rate of disapproval is realised in Fig. 10 for the battery life of wearable devices meeting expectations, with the highest rate of neutrality.

3.6. Subjective Impressions

Regarding this thesis' research hypothesis model, subjective impressions are assumed to have a positive impact on perceived usefulness and perceived ease of use.

In this category, only a rather small majority of the 154 participants seem to be favourable of the statements given in the seven items.

The highest rate of approval of this section can be seen in Fig. 11 with the statement that they feel physically comfortable wearing a wearable device. The highest approval rate for wearable devices is 61%, with only 10% disagreeing.

The highest rate of disapproval can be seen in Fig. 12. When asked whether the participants feel well informed by the producer about the usage of their health data only 22% approve of producer's use of health data, while 37% disagree or strongly disagree.

3.7. Concerns

Unlike all the other variables of the research hypothesis model, concerns actually have negative impacts on perceived usefulness and perceived ease of use. Hence, "negative" results as high disapproval rates are desirable.

However, there are still some high approval rates that need to be discussed. Figs. 13 and 14 show the two highest approval rates. In Fig. 13, participants are concerned about wearables being used to track them or create movement profiles.

Similarly, in Fig. 14, participants are concerned about the use of their private health data by producers, but disapproval is low.
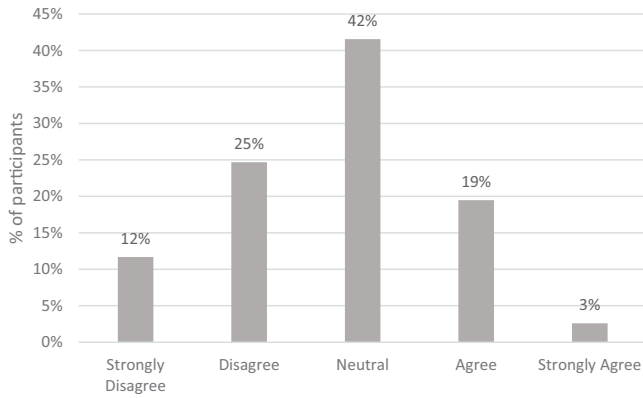
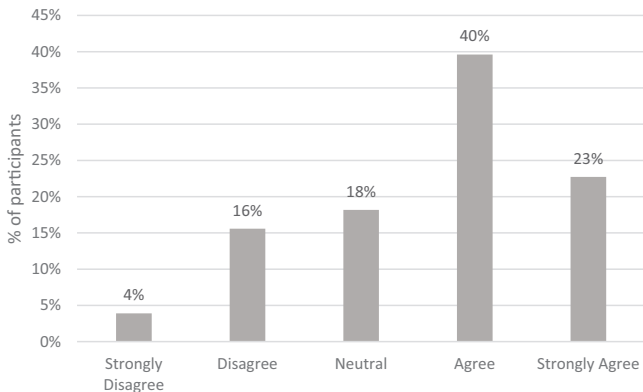Fig. 12. Participants feeling well informed their health data usage.

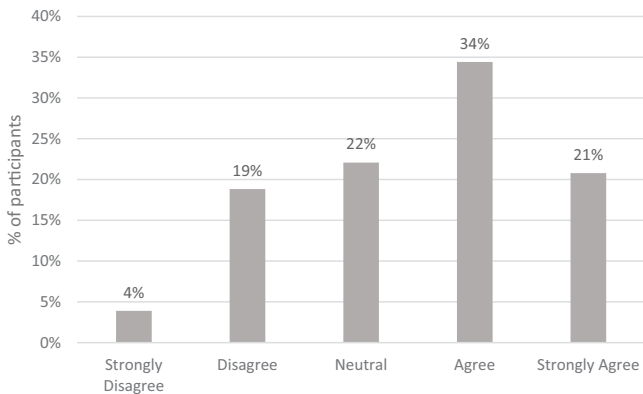Fig. 13. Participants being concerned that wearables can be used to track them.

Fig. 14. Participants worrying about the usage of private health data.

3.8. Social Influence

Unlike concerns, social influence behaves exactly like the rest of the variables of this research hypothesis model, so it has a positive impact on perceived usefulness and perceived ease of use, meaning in this case higher approval rates are desired again.

Participants felt comfortable sharing data collected by wearable devices with medical professionals (Fig. 15) but felt uncomfortable sharing their experiences on social media, leading to a 52% disapproval rate (Fig. 16).

4. Discussion

Based on the findings of this survey, the majority of Deggendorf Institute of Technology students approve of
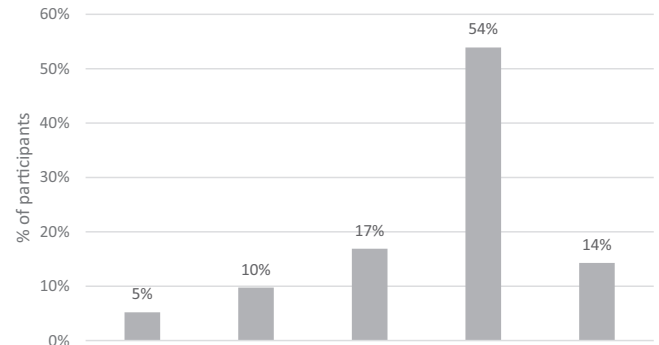

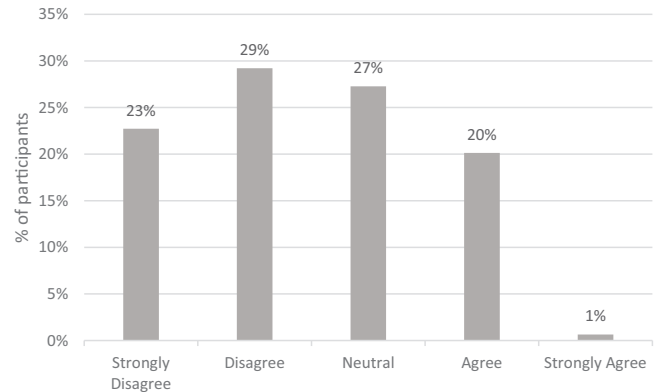Fig. 15. Participants feeling comfortable sharing the data with doctors.

Fig. 16. Participants feeling comfortable sharing their data online/on social media.

wearable healthcare technologies, with majority believing they will help prevent chronic diseases and lead to a healthier society.

However, despite a strong majority of participants believing that digital health technologies will both help prevent chronic diseases and lead to a healthier society overall, they do not seem to be as convinced by the idea that wearables may help users live longer at home. These findings seem to be somewhat conflicting as most participants still agree that wearables can help improve a user's health overall.

Arguably the biggest issue that needs to be discussed is the concerns, specifically those related to data protection of sensitive health information. More than half of all participants are concerned about the usage of their private health data by the producers of wearable devices and even that the data collected by those devices may be used to track or create movement profiles of the users.

These data protection issues might also be the reason why only a quarter of participants felt comfortable sharing data collected by wearables on social media platforms, while the majority felt comfortable sharing it with medical professionals. This may be caused by a certain distrust towards international social media platforms processing data outside of Germany or even outside the EU and therefore outside of the GDPR domain [10].

More technologically experienced users have the highest approval rate for wearable technologies. Wearables are popular with younger people, finding them easy to set up, install, connect, and remove. Further research is needed to determine if acceptance of wearable technologies is as high as it is with younger people if PEOU values drop.

5. Conclusion

Surveying 154 students of the Deggendorf Institute of Technology majority of the participants had a favourable attitude towards health technologies. However, nearly more than a quarter of the participants had data protection concerns in using wearables in their everyday lives. Therefore, this research suggests improvement in data protection management and creating more transparency to enable users to make informed decisions about their health data. Further research is needed to understand what elderly people and those with chronic illnesses think of wearables and digital health.

Conflict of Interest

Authors declare that they do not have any conflict of interest.

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