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Continuously monitoring the human machine? – A cross-sectional study to assess the acceptance of wearables in Germany

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Abstract

Background: Wearables have the potential to transform healthcare by enabling early detection and monitoring of chronic diseases. This study aimed to assess wearables' acceptance, usage, and reasons for non-use. **Methods:** Anonymous questionnaires were used to collect data in Germany on wearable ownership, usage behaviour, acceptance of health monitoring, and willingness to share data. **Results:** Out of 643 respondents, 550 participants provided wearable acceptance data. The average age was 36.6 years, with 51.3% female and 39.6% residing in rural areas. Overall, 33.8%

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reported wearing a wearable, primarily smartwatches or fitness wristbands. Men (63.3%) and women (57.8%) expressed willingness to wear a sensor for health monitoring, and 61.5% were open to sharing data with healthcare providers. Concerns included data security, privacy, and perceived lack of need. **Conclusion:** The study highlights the acceptance and potential of wearables, particularly for health monitoring and data sharing with healthcare providers. Addressing data security and privacy concerns could enhance the adoption of innovative wearables, such as implants, for early detection and monitoring of chronic diseases.

Keywords
wearable, health monitoring, data privacy, user acceptance, chronic disease

Introduction

The prevalence of many diseases is increasing worldwide. There are various reasons for this, including environmental and climate change, as well as unhealthy lifestyles.[1,2] Recent technological advances and the increasing digitalisation of healthcare have the potential to address these challenges. In the dynamic field of healthcare, the importance of wearable technologies for continuous monitoring is constantly increasing. These technologies have the potential to effectively monitor patients, improve diagnoses and optimise therapies by tailoring them to the individual needs of each individual.[3,4] In the present context, smart wearables are electronic devices designed to be worn close to or on the surface of the skin. These devices are capable of continuously collecting, analysing and transmitting data related to various body signals, including vital signs, biomarkers and environmental information.[5–9] An important application of wearable technology is ecological momentary assessment (EMA), which evaluates a person's behaviour and experiences in their natural environment in real time.[10,11] This method provides valuable insights into a person's state of health. Ecological momentary intervention (EMI) uses the data to take timely action and improve patient care through personalised and contextualised health strategies.[10,11] These applications demonstrate the potential of wearable devices to provide adaptive and timely healthcare treatments. Around 28% of the German population used wearables to monitor their physical activity in 2016.[12,13] Wearables are different types of devices such as smartwatches, fitness trackers, rings, hearables and special devices that can collect data via the skin.[14–21] Innovative wearables can capture a whole range of measurement data that goes beyond conventional functions such as step counting or heart rate. One possible application of this technology is, for example, the monitoring of alcohol consumption.[22,23] This enables continuous and non-invasive measurements that provide both healthcare professionals and individuals with valuable information to detect significant changes in health status. In addition, this technology provides an innovative way to address health issues and encourage people to adopt healthier lifestyles. Wearables can be divided into different functional subtypes, such as microneedle patches,[12] electronic trans-epidermal tattoos used for non-invasive cortisol measurement via sweat,[9,12] and e-textiles,[14,24] which are characterized by the integration of sensors into clothing.[15,24] The use of wearables in healthcare practice could support and optimize diagnostic and treatment decisions through the continuous monitoring and processing of data collected on an ongoing basis.[17,24,25] Furthermore, patients can become more involved in the monitoring of their health status, resulting in possible time savings and cost reductions for patients and physicians.[9,26–28] However, studies on the acceptance of wearables for health monitoring in connection with data sharing in the daily routine are limited.

The primary aim of this research study is to investigate the acceptance and usage behaviour of wearables in Germany. The study aims to investigate the willingness of individuals to use wearables for health monitoring, to identify the factors that influence the use of wearables and to examine the associated risks and barriers. In addition, the study aims to capture the demographic characteristics of wearable users and non-users.

Methods

Study design and population

This cross-sectional study adheres to the STROBE statement and guidelines.[29,30] Data collection was conducted from July to September 2022 using a convenience sampling technique. Participants were recruited through a multi-channel approach that involved both online and offline methods. The online questionnaire was disseminated via various websites (e.g., university, forums), as well as popular social media platforms, selected for their high traffic and accessibility. In addition, paper-based questionnaires were distributed at an international fair ("Interforst") that provided access to a diverse group of interested attendees. This venue was part of a health campaign by the German Social Insurance for Agriculture, Forestry, and Horticulture. For this study, the sample size calculation was performed using G-Power 3.1.9.6,[31] with an effect size of 0.2 being specified. The probability of a Type I error was set at $\alpha = 0.05$, while the probability of a Type II error was set at $\beta = 0.2$, resulting in a power of 80%. The total sample size calculated for our study was 788 participants. This study was approved by the ethics committee of this study was approved by the ethics committee of the Technical University Munich (reference number 2022-314-S-NP).

Inclusion criteria and missing values

Inclusion criteria for participation were being aged ≥18 years and written informed consent. Participants who did not provide information on the acceptance of wearables ($n = 93$) were excluded. To ensure data quality, participants who answered less than 80% of the questionnaire were excluded from analyses. For the Poisson regression, a further 12 participants had to be excluded due to missing values.

Study questionnaire

A self-designed questionnaire was used. Questions on the acceptance of wearables were based on previous acceptance studies[32–40] that focussed on digital tools and wearables such as fitness trackers. The selected questionnaires were first translated into German. To ensure that our questionnaire comprehensively covered all relevant aspects of user acceptance, we designed it considering key components from the Technology Acceptance Model (TAM) and the Unified Theory of Technology Acceptance and Use (UTAUT). TAM, developed by Davis et al.,[40] is based on two main determinants: perceived usefulness and perceived ease of use. For our study, these concepts were adapted to assess beliefs about enhancing health monitoring through wearables and the effortlessness of their use. UTAUT, proposed by Venkatesh et al.,[41] extends TAM by including performance expectancy, effort expectancy, social influence, and facilitating conditions. In the context of our study, these constructs helped assess beliefs about the wearables. In the paper by Yang et al.,[35] the acceptance questions based on TAM and UTAUT are tested validated instruments. The questionnaire was reviewed by three authors with expertise in dermatology, public health, and statistics. Prior to the main study, we conducted a pilot test with five randomly selected participants. This step allowed us to gather initial feedback and make minor revisions, such as expanding the answer options for closed questions or the translation. Forty-two questions were divided into four sections:

1. Sociodemographic data and current usage of wearables (Table 1, Figure 1)
2. Usage behaviour of wearables among current users (Table 2, Figure 2)
3. Willingness to share data from wearable and with whom (Figure 3)
4. Willingness to wear wearables for health monitoring in the future (e.g., implants) (Figure 4–6)

Table 1. Characteristics of respondents.

	Total (*n* = 550)	Wearable user (*n* = 186, 33.8%)	Wearables non-user (*n* = 364, 66.2%)	*p*-value
Gender				.025
Male	323	97 (30.0%)	226 (70.0%)	
Female	227	89 (39.2%)	138 (60.8%)	
Age				.661
18 – 25	121	41 (33.9%)	80 (66.1%)	
26 – 35	224	78 (34.8%)	146 (65.2%)	
36 – 45	62	21 (33.9%)	41 (66.1%)	
46 – 55	68	26 (38.2%)	42 (61.8%)	
56 and older	75	20 (26.7%)	55 (73.3%)	
Place of residence				.037
Small town to rural community (<19,999)	306	92 (30.1%)	214 (69.9%)	
Medium-sized town to large town (>20,000)	244	94 (38.5%)	150 (61.5%)	
Physical activity per week (hours)				<.001
< 1	87	19 (21.8%)	68 (78.2%)	
1 < 2	157	49 (31.2%)	108 (68.8%)	
2 < 4	154	48 (31.2%)	106 (68.8%)	
> 4	152	70 (46.1%)	82 (53.9%)	
Salary per month (€)				.069
< 1,000	100	36 (36.0%)	64 (64.0%)	
1,000 < 2,000	96	36 (37.5%)	60 (62.5%)	
2,000 < 3,000	178	46 (25.8%)	132 (74.2%)	
3,000 < 4,000	101	38 (37.6%)	63 (62.4%)	
> 4,000	63	28 (44.4%)	35 (55.6%)	
Missing	12			
Education				.045
Lower than high school degree	208	57 (27.4%)	151 (72.6%)	
High school degree	106	41 (38.7%)	65 (61.3%)	
University/doctoral degree	236	88 (37.3%)	148 (62.7%)	
Reasons for non-use of wearables (multiple responses)				
Data protection risk			36 (9.9%)	
Too expensive			59 (16.2%)	
No benefit in use			184 (50.5%)	
Other (lack of knowledge/interest)			72 (19.8%)	

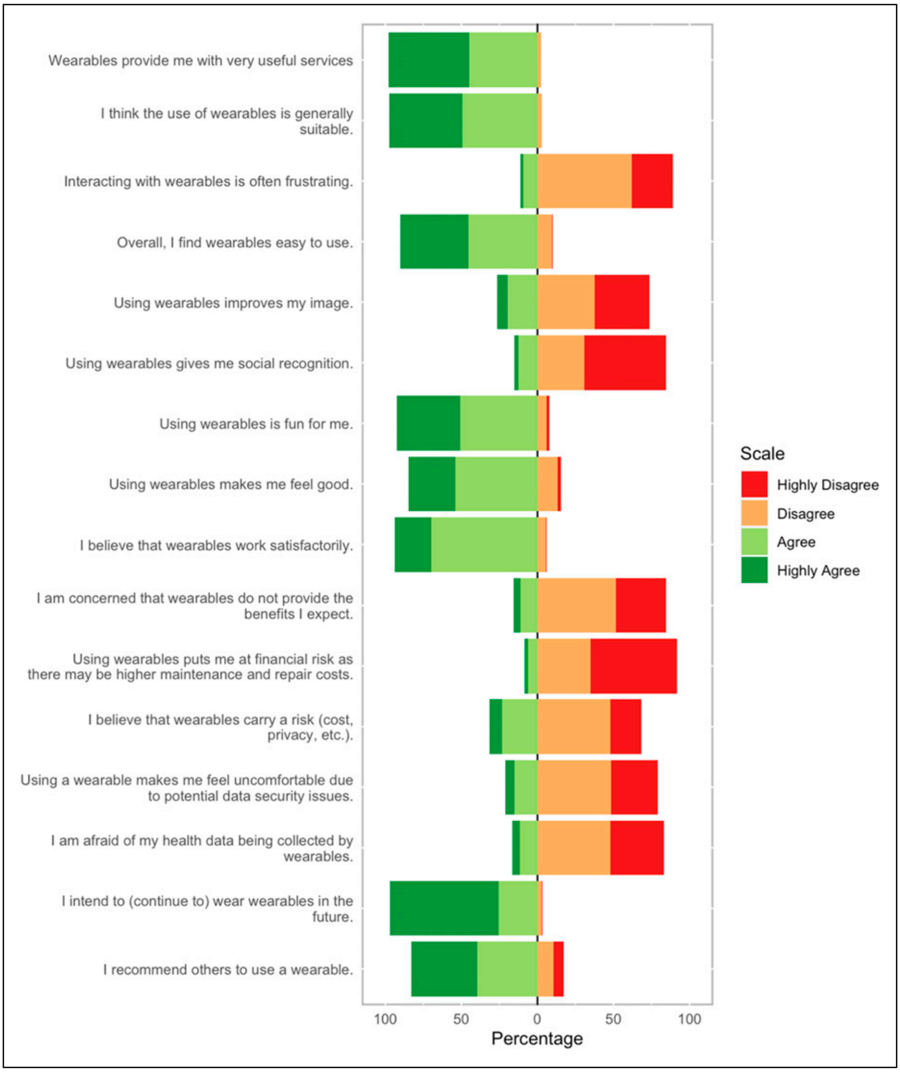

Figure 1. Responses and attitudes among wearable users.

Wearables were defined in the survey as any wearable electronic device that is worn on the body to collect and analyse information about e.g., body signals and/or environmental data.[42] Except for age, variables were predominantly collected as nominal or ordinal variables. The age of the study participants was divided into five age groups to compare between younger and older users: 18 to 25 years, 26 to 35 years, 36 to 45 years, 46 to 55 years, and 56 years and older. Furthermore, study participants were classified according to their place of residence, physical activity, monthly income, and education level. Places of residence were classified as rural communities (<5,000 residents), small towns (5,000–19,999 residents), medium-sized towns (20,000–99,999 residents), and large towns (>100,000 residents). To assess the physical activity per week, we employed a question from the German-validated

Table 2. Frequency of use and type of measurements among wearables users (*n* = 186) as well as associated risk of and barriers to using wearables (*n* = 517).

Question and responses	*n* (%)
What kind of wearable do you use?	
Total respondents	185
Total responses	198[a]
Smart watch	122 (61.6%)
Fitness wristband	60 (30.4%)
Smart ring	8 (4.0%)
Other[b]	8 (4.0%)
If you use a wearable, how often?	
Total respondents	185
Total responses	185
Daily	120 (64.9%)
Several times a week	46 (24.9%)
Once a week	3 (1.6%)
Several times a month	7 (3.8%)
Rarely	9 (4.9%)
How long have you owned your wearable?	
Total respondents	184
Total responses	184
Less than 1 year	39 (21.2%)
Between 1 and 2 years	56 (30.4%)
More than 2 years	89 (48.4%)
What data do you measure with your wearable?[c]	
Total respondents	185
Total responses	772
Pedometry	166 (89.7%)
Pulse	165 (89.2%)
Jogging distance	139 (75.1%)
Calorie consumption	119 (64.3%)
Sleep activity	82 (44.3%)
Breathing rate	40 (21.6%)
Blood pressure	18 (9.7%)
Body temperature	11 (5.9%)
Monitoring of the menstrual cycle	10 (5.4%)
Blood sugar	4 (2.2%)
Other (Electrocardiogram, oxygen saturation)	18 (9.7%)
What risks do you see in the use of wearables?[c]	
Total respondents	517
Total responses	829
Gaps in data protection	261 (50.5%)
No need, as satisfied with current analogue solutions	110 (21.3%)
Too little knowledge about wearables	91 (17.6%)
High costs	81 (15.7%)

(continued)

Table 2. (continued)

Question and responses	*n* (%)
Do not see any risk	67 (13.0%)
Too little evidence of benefits	66 (12.8%)
Lack of usability	57 (11.0%)
Poor quality	56 (10.8%)
Other[d]	40 (7.7%)
How much would you be willing to pay for a wearable?	
Total respondents	385
Total responses	385
Mean (SD)	165 (±141.53)
0	43 (7.8%)
1 – 50	60 (10.8%)
51 – 100	83 (15.0%)
101 – 200	94 (17.0%)
201 – 300	64 (11.6%)
> 300	41 (7.4%)
Missing	169 (30.5%)

[a]Some participants owned more than one wearable.
[b]Other: Chest straps.
[c]Total sums may exceed 100%, as multiple answers were possible.
[d]Other: Dependence, data validity, permanent monitoring not desirable.

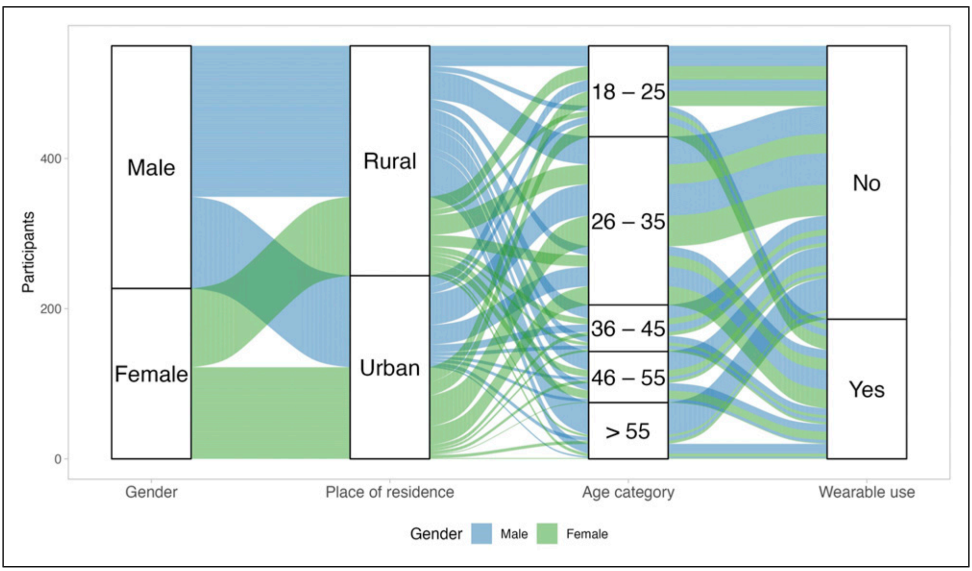

Figure 2. Characteristics of participants and wearable use.

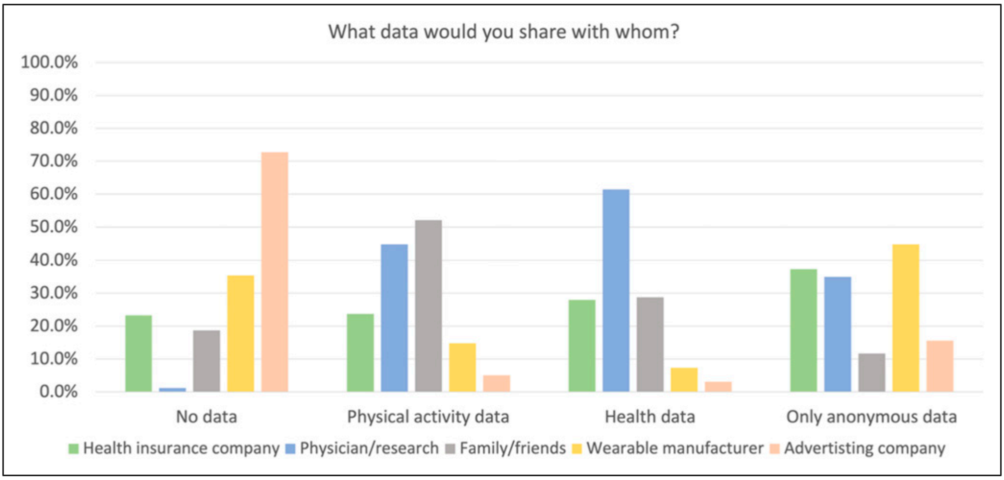

Figure 3. Frequency of willingness to share data measured by wearables for different types of data (total respondents = 257).

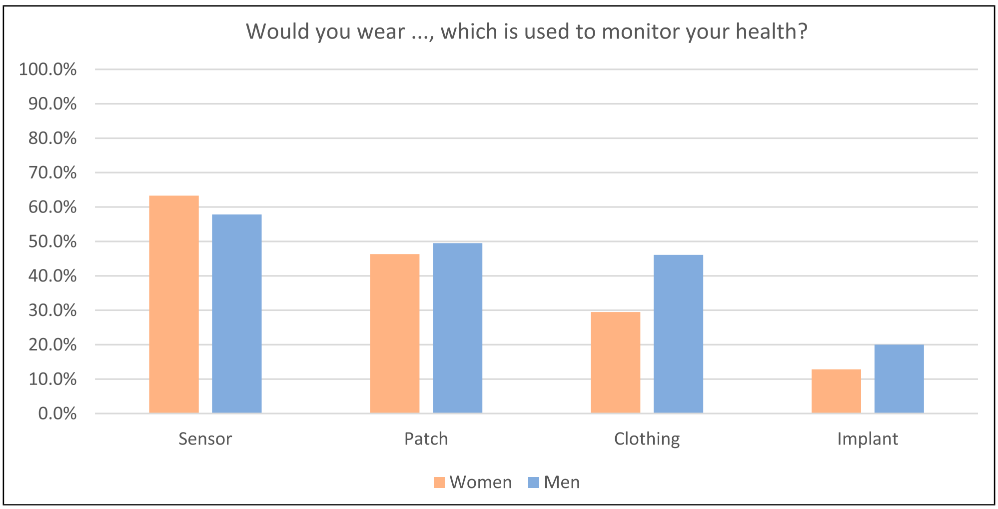

Figure 4. Frequency of willingness to wear various wearables (men and women who responded with "yes" in each category).

version of the European Health Interview Survey (EHIS-PAQ).[43] "How much time in total do you spend on sports, fitness or recreational (leisure) physical activities in a typical week?". For comparison between participants with different physical activity levels, the variable was included with four different categories ("< 1", "1 < 2", "2 < 4", ">4" hours). For comparison between different incomes, the variable "salary per month (€)" was included with five different categories ("<1,000" to ">4,000"). The variable "education level" comprises three categories, including "lower than high school degree", "High school

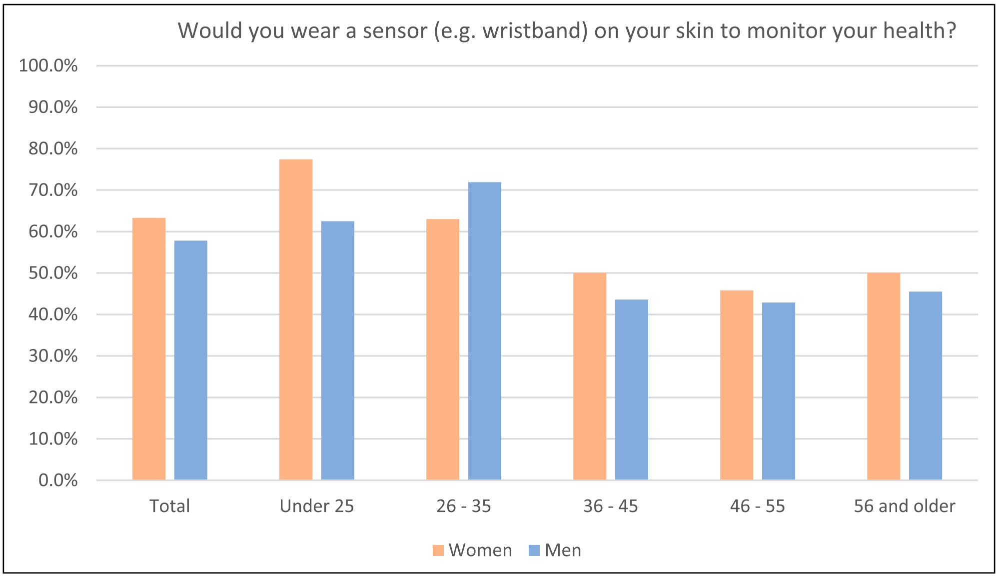

Figure 5. Frequency of willingness to wear a sensor to monitor health ("Yes Responder" of total 257 responders).

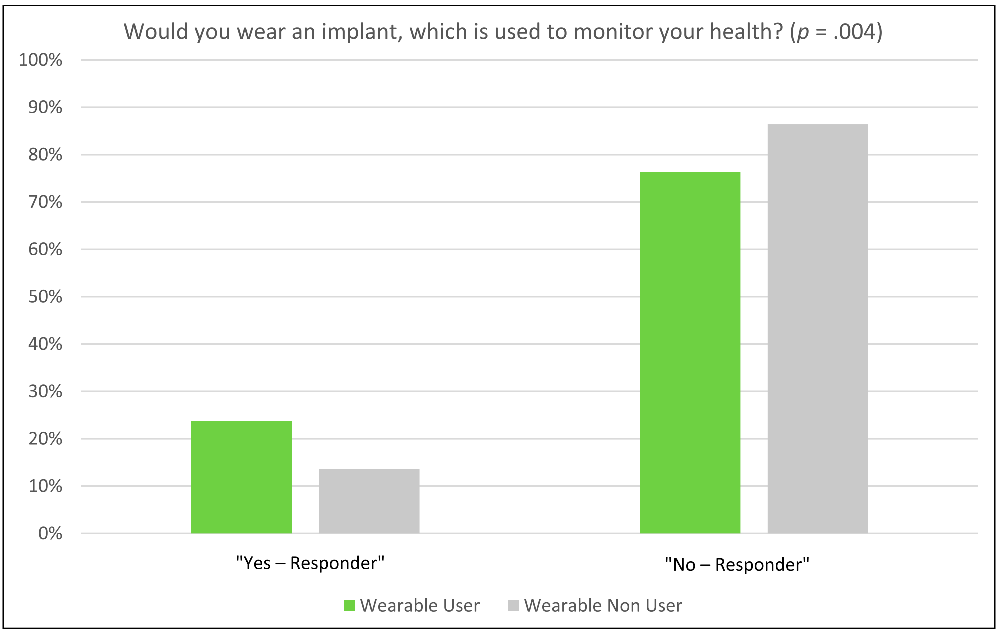

Figure 6. Frequency of willingness to wear an implant to monitor health ("Yes-responder" of total 257 responders).

degree", and "University/doctoral degree". Study data were collected, digitised, and managed using REDCap (Research Electronic Data Capture, Vanderbilt University).[44,45]

Statistical methods

Data management and statistical analyses were conducted using R version 4.2.1[46,47] and IBM SPSS Statistics 28 (IBM Corporation, Armonk, NY, USA). All variables were analysed descriptively using absolute and relative frequencies. Associations between current wearable users and non-users with other variables were tested using Chi-square tests. The Generalized Linear Model (GLM) with a Poisson distribution[48,49] was employed to investigate the association between the use of wearable devices and various predictors, including gender, place of residence, age, physical activity per week, survey location, and monthly salary. Results of the regression model are presented as prevalence ratios (PR) with their 95% confidence interval (CI). The significance level was set to $\alpha = 0.05$.

Sensitivity analysis

To ensure data quality, participants who answered less than 80% of the questionnaire were excluded and not included in the analyses. For the Poisson regression, missing values were excluded from the analysis. Sensitivity analyses were conducted to quantify response biases due to missing information regarding the willingness to use wearables. For this purpose, the acceptance of wearables was calculated for two fictitious scenarios in which all individuals with missing information on the willingness to use wearables were either open (scenario 1) or not open (scenario 2) to using wearables. Another sensitivity analyse All study participants were included in this analysis. In addition, confidence intervals were calculated using the bootstrap method (1000 bootstrap samples, $\alpha = 5$).

Results

Overview

In terms of the survey administration, 235 (42.7%) participants completed the survey using a paper and pencil questionnaire, while 315 (57.3%) participants completed the survey online. Of the 403 online questionnaires initiated, 315 were successfully completed, resulting in an online response rate of 78%.[50]

A total of 550 participants were included in this study (Table 1). Participant age ranged between 18 and 81 years, and the mean age was 36.6 years (standard deviation: 13.9). A total of 186 participants (33.8% of the total sample) reported using wearables, with 39.2% of female respondents and 30.0% of male respondents using wearables ($p = .025$). There was no statistically significant difference in the distribution of wearable users across age groups. For participants aged 18 to 55, 33.9% to 38.2% of participants reported using a wearable depending on the age group ($p = .661$). Although the proportion of participants reporting wearable use decreased to 26.7% in the age Group 56 years and older, the difference was not statistically significant ($p = .661$). There were more wearable users in the medium-sized and large towns (38.5%) than in the small towns and rural communities (30.1%) ($p = .037$).

Regarding physical activity, the largest proportion of wearable users (46.1%) was observed for the category of ">4" hours of exercise per week, which was significantly higher than the percentages observed in the categories with less than 4 h of exercise per week ($p < .001$). Although the proportion of wearable users was highest in the category of monthly income of more than 4,000€ (44.4%), the difference was not statistically significant when compared to categories for lower monthly income (p = .069). The proportion of wearable users was higher in the category of "High school degree" (38.7%) and "University/doctoral degree" (37.3%) than in the category of "lower than high school degree" (27.4%) (p = .045).

Reasons for non-use

The most prevalent reason, mentioned by 50.5% of non-users, was the perception of no tangible benefit from using wearables. For 16.2% of non-users, cost presented a substantial concern. Approximately 9.9% expressed concerns about data protection and privacy associated with wearables. Furthermore, about 19.8% of non-users fell into the "Other" category, citing various reasons such as a lack of knowledge or interest in wearables.

Usage patterns

Among all 186 wearable users, 122 people owned a smartwatch, 60 people owned a fitness wristband, eight people owned a smart ring, and another eight owned other wearables like chest straps for sports or smart patches for insulin measurement (Table 2). About 90% of users stated that they use their wearable more than once a week, of which 64.5% used it daily. The most common measurements recorded with the wearables were the number of steps walked (89.7%), pulse (89.2%), distance jogged (75.1%), calories consumed (64.3%), and sleep activity (44.3%).

Data sharing and sensor use

Our results show that 61.5% of respondents (158 out of a total of 257 respondents) would share their wearable health or physical activity data (44.7%) with their doctor or a researcher (n = 273) (Figure 3). In addition, 42.7% of participants would only share anonymous data with wearable manufacturers. The willingness to wear a health monitoring sensor on the skin was found in 57.8% of men and 63.3% of women among all respondents (Figure 4). (Figure 5) Participants were more willing to wear a (sensor) patch (46.3 % men, 49.5 % women) than a garment with sensors (46.1 % men, 29.5 % women) or a health monitoring implant (20.0 % men, 12.8 % women) (Figure 6). In the wearable user category, the willingness to wear an implant (23.7 %) is higher than in the non-user category (13.6 %) (Figure 6).

Concerns about wearables

Overall, 517 participants responded to the question about the risks and barriers they associate with the use of wearables (Table 2). In most cases, concerns were raised about data protection (50.5%), followed by "no need for wearables" (21.3%), "too little knowledge about wearables" (17.6%), and "high costs" (15.7%). Among all respondents, 13.0% saw no risk at all in using wearables, and 40 respondents provided additional comments specifying the risks they associated with the use of wearables, such as dependence on the device, no confidence in data validity of measurements, and rejection of permanent monitoring.

Factors influencing the use of a wearable

Gender yielded a prevalence ratio (PR) of 1.253 (95% CI: 0.905 to 1.735), indicating a slightly increased, but not statistically significant, prevalence of wearables use among women compared to men (p = .174). In terms of physical activity per week, individuals who were physically active for more than 4 h showed a significantly higher prevalence of wearable use (PR = 1.913; 95% CI: 1.142 to 3.203; p = .014) compared to individuals with less than 1 h of activity per week. Survey location (online vs paper) showed a significant difference in the use of wearables, with a PR of 1.920 (95% CI: 1.309 to 2.816) for online respondents (Table 3).

Sensitivity analysis

The sensitivity analyses confirmed the robustness of the primary results (Appendix 1). One analysis involved participants with paper-based questionnaires where gender had a significant effect on wearables use (PR = 2.280, 95% CI: 1.213 – 4.289, p = .011). Further analysis with online questionnaire participants showed that higher levels of physical activity (>4 h per week) significantly predicted wearables use (PR = 1.917, 95% CI: 1.021 – 3.599, p = .043), mirroring the primary findings. No other factors such as place of residence, age or salary showed significant effects.

TAM and UTAUT constructs in wearables acceptance

In the analysis of the constructs of TAM and UTAUT, the reliability assessment for the construct of perceived usefulness resulted in a Cronbach's alpha of 0.798. The construct of perceived ease of use showed a Cronbach's alpha of 0.444. A Cronbach's alpha of 0.62 was determined for the intention to use construct.

Table 3. Results of the Poisson regression with wearable use as a dependent variable and gender, place of residence, age, and physical activity as independent variables.

	PR	95% CI	p – value
Gender (Reference: Male)	1.253	0.905 – 1.735	.174
Place of residence (Reference: rural)	1.018	0.736 – 1.409	.912
Age (years) (Reference: Under 25)			
26 – 35	0.986	0.620 – 1.566	.951
36 – 45	1.154	0.625 – 2.129	.648
46 – 55	1.411	0.792 – 2.514	.242
56 and older	1.306	0.702 – 2.432	.399
Physical activity per week (hours) (Reference: <1 h)			
1 < 2	1.247	0.729 – 2.132	.344
2 < 4	1.233	0.720 – 2.112	.385
>4	1.913	1.142 – 3.203	.001
Location of survey, (Reference: At trade fair)	1.920	1.309 – 2.816	<.001
Salary per month (€) (Reference: <1,000)			
1,000 < 2,000	1.089	0.660 – 1.798	.739
2,000 < 3,000	0.864	0.513 – 1.456	.583
3,000 < 4,000	1.145	0.660 – 1.987	.630
>4,000	1.339	0.733 – 2.447	.343

PR: Prevalence ratio, CI: confidence interval

Discussion

Key results

The main objective of our study was to investigate the acceptance and usage behaviour of wearables in the German population. The results showed that 33.8% of participants reported using a wearable - mainly to measure physical activity. In addition, a high proportion of respondents (57.8% of men and 63.3% of women) showed a willingness to use wearables with health monitoring sensors, indicating a positive attitude towards modern health technology.[50] This trend was more pronounced among women and people with higher activity levels, consistent with other studies.[51,52] Individuals who set health-related goals, such as those related to physical activity, will likely find wearables useful for monitoring their progress toward these goals.[50,51,53] Regarding data-sharing preferences, participants showed a clear inclination to share health data with healthcare providers rather than other organisations, highlighting an important aspect of privacy and security in digital health. These aspects align with other results of studies in this field.[8,51,54,55]

Innovative wearables may have great potential for empowering individuals, especially in the medical field, when it comes to diagnosis, behavioural changes, and monitoring of chronic diseases.[7,26,56–58] For example, Hirten et al.[59] showed that wearables can provide important information for patients and can be a suitable approach to routine management of diseases. Our study confirms that people who already use wearables are more open to innovative wearables like implants for monitoring their health.[33,34,50] Our findings regarding the association between physical activity and wearable use are consistent with the findings of the study by Chandrasekaran et al.[51] who reported that people who consider themselves healthier and lead a more active lifestyle are more likely to use a wearable.

Limitations

There are a few limitations in our study that could affect the interpretation of the results. One limitation is the sampling method. As part of the data collection at a fair, it is plausible that this venue attracted individuals with a pre-existing interest in or knowledge of wearable technologies. This selection bias could lead to overestimating the acceptance and usage rates of wearables. Self-report in data collection raises the possibility of recall bias, in which participants do not accurately remember their usage behaviour or preferences, and social desirability bias, which causes them to give responses that they perceive as more favourable or acceptable. In addition, demographic bias, with an average age lower than the national average and a potential over-representation of male participants, could limit the representativeness of the results.[60] The direction of bias created by these limitations is likely to be towards an over-representation of positive attitudes towards wearable technology, and the extent of this bias, although difficult to quantify, could influence important findings.

Interpretation

The Interpretation of these results requires careful consideration of the study objectives and limitations, as well as the context provided by similar studies. The high levels of acceptance and willingness to use wearables for health monitoring found in our study are consistent with global trends in the adoption of digital health technologies.[61–63] However, these findings may represent an optimistic view of wearables uptake, given the methodological limitations of the study. Concerns about privacy and data security are consistent with broader challenges in digital health, highlighting the need for robust data protection measures to encourage wider adoption. Comparisons with similar studies underscore the potential of wearable technologies in healthcare and highlight the common hurdles of privacy and demographic representativeness.[6,9,25,64–67]

Generalizability

To increase the generalizability of the study results on wearables for health monitoring, an extension to the medical context should be considered. Including patients could provide information on how wearables can be used specifically to monitor health conditions and support therapeutic measures. This would enable an understanding of efficient use under the requirements of the healthcare sector (e.g. data protection, reliability). Expanding the study population to include different age groups and socioeconomic backgrounds would also help to develop a more comprehensive understanding of the acceptance and use of wearables beyond the younger, tech-savvy population included in this study.

Conclusion

This study investigated the acceptance and perception of wearables and found that most people have a positive attitude towards wearables. The wearables used were mainly used to monitor physical activity. The high willingness to use wearables for continuous health monitoring and to share health data with healthcare providers offers great potential. However, secure digital solutions are needed to address concerns such as data security. Further research is needed to learn more about the acceptance and benefits of wearables in medicine, e.g., microneedles or implants, which offer great potential for continuous monitoring and improvement of patient care in the context of personalized medicine.

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Authors' contributions

M.H. conceived and designed the analysis, did the data collection, performed the analysis, and wrote the paper. H.W. supported the data collection and analysis and reviewed the paper. A.Z. conceived and designed the analysis and reviewed the paper. T.B. reviewed the paper.

Declaration of conflicting interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: The Authors declare no Competing Financial Interests but the following Competing Non-Financial Interests. AZ - Chairman of the Digital Dermatology Working Group, German Society of Dermatology. Development of wearables funded by the German Federal Ministry for Economic Affairs and Climate Action (BMWK) based on a decision by the German Bundestag. All other Authors have no competing interests.

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Ethical statement

Ethical approval and consent to participate

The study was reviewed and approved by the responsible ethics committee of the Faculty of Medicine at Technical University of Munich (2022-314-S-NP) and was conducted in accordance with national law and the Declaration of Helsinki. Patients' informed consent to participate was obtained prior to the study.

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Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Supplemental Material

Supplemental material for this article is available online.

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