User experiences and perceptions of health wearables: a cross-sectional study in Cambodia

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Abstract

Background: In many low- and middle-income countries (LMICs), health system capacities to address the burden of non-communicable diseases (NCDs) are often inadequate. In these countries, wearable health technologies such as smartbands and smartwatches could be used as part of public health programmes to improve the monitoring, prevention, and control of NCDs. Considering this potential, a study was conducted in Cambodia to explore user experiences and perceptions of a watch-type health wearable, including utilisation patterns, perceived usefulness and usability, and willingness to pay.

Methods: Data collection involved a baseline survey, conducted in 2019 with different categories of participants (including hypertensive participants, non-hypertensive participants, postgraduate students, and civil servants), and a follow-up survey with the same participants, one month after they were given a sample of the wearable and advised to wear it day and night. Results were analysed using descriptive statistics, test statistics, and binomial regression to predict the utilisation of the paired smartphone application.

Results: A total of 156 adult participants completed the baseline and follow-up surveys. The reception of the technology was positive overall: 89.1% of the participants said they would continue using the watch and 76.9% of them would recommend it to either friends or relatives, while 94% said the device stimulated them to think more frequently about their health\. However, challenges to technology acceptance were identified, including concerns with the accuracy and quality of the device and unfamiliarity with the concept of health self-monitoring, especially among the elderly. Short battery life and cost were also identified as potential barriers to continued use.

Conclusions: Health wearables are a promising new technology that could be used in Cambodia and in other LMICs to strengthen health sector responses to the challenges of NCDs. However, this technology should be carefully adapted to the local context and the needs of less resourced population groups. In addition, further research should investigate if adequate health sector support and infrastructure are in place to implement and sustain the technology.

Background

It is well known that low- and middle-income countries (LMICs) are experiencing a rising burden from non-communicable diseases (NCDs). In 2018, NCDs accounted for 41 million deaths worldwide and nearly 85% of premature deaths from NCDs occurred in LMICs [1]. Recent projections indicate that deaths due to NCDs in LMICs may increase to 70.5 million by 2060 [2].

In light of this, international and national efforts to address NCDs and known risk factors such as poor diet, tobacco use, and physical inactivity have intensified. However, health system capacities to prevent and control NCDs are still inadequate in many LMICs [3]. In Cambodia, it is estimated that NCDs –

particularly cardiovascular diseases – account for 64% of all deaths [1]. In line with global health policy, the Ministry of Health and international partners developed a national plan on NCDs amidst concerns that Cambodia will face "a tsunami of additional NCD patients in the coming years" [4]. Provisions for NCD management at the primary care level are however lagging [5, 6]. In addition, as in many other LMICs, the health information system in Cambodia is not sufficiently developed to account for the multi-dimensional complexity of NCDs [7] and only two major surveys of NCD risk factors were conducted in the past two decades [8].

In this context, wearable health technologies such as smartbands and smartwatches could be used as part of public health programmes to improve the awareness, prevention, monitoring, and control of NCDs. In recent years, a wide range of wearable devices have entered the consumer market, designed to capture various biometric data, including heart rate, mobility, sleeping patterns, and calories spent. Furthermore, clinical grade devices with more advanced features such as blood pressure measurement, biomarkers for blood glucose, and hydration level are available [9]. Unlike data collection in clinical settings, these devices allow for continuous, unobtrusive, and ecologically valid data collection in real-world environments. As such, they could be deployed in both rural and urban communities to conduct regular surveys of risk factors for NCDs and their distribution across population groups, providing key evidence to inform policy development and programme implementation. In addition, health wearables could link users with the local health system, contributing to improved disease prevention, monitoring and management. However, successful uptake of health technologies is not only dependent on the fixed technical properties of new devices, but also requires acceptance and appropriate use by motivated people [10]. Thus, an understanding of technology acceptance by target users in the communities is crucial to inform policy decisions and technology introduction. While studies of user experiences with health wearables have been conducted [11, 12], these have focused on high-income countries and little is known about the reception of this type of device in LMICs. Our study addresses this research gap by exploring utilisation patterns and views about a watch-type health wearable in Cambodia.

Methods

Study design and participants

The research design for this study was guided by existing theories suggesting that technology uptake is largely influenced by two key aspects: perceived usefulness and perceived usability [13]. Perceived usefulness is generally defined as the extent to which a person believes that using the technology would enhance her or his performance (in this case health and wellbeing); perceived usability refers to the extent to which a person believes that using the technology will be free of effort or hurdles [13]. Existing models also recognise that demographic characteristics and socioeconomic status have considerable impact on technology uptake and sustainability [14]. Drawing on these concepts, in 2019 we designed and conducted a baseline and a follow-up survey in Phnom Penh, Cambodia's capital, and Kampot, a rural province in the southwest of the country to explore users' experiences with a watch-type health wearable, including their: (1) utilisation patterns; (2) views on usefulness and usability; and (3) willingness to pay.

At baseline all participants were provided with a sample wearable, produced by a manufacturer in Shenzhen (China). This device could be used to tell the time and measure heart rate, blood pressure, steps, and track calories using an entirely graphical interface. The device could be paired to a dedicated smart phone application providing basic statistics of user data and trends over time. All participants were advised to wear the watch as much as possible, day and night. In conjunction with product delivery, demographic and health information was collected for each participant. One month after product delivery, a follow-up survey was conducted with the same participants to collect their views and experiences with the device. Given the exploratory nature of this study and limited supply of the study watch, we did not use representative sampling but we aimed to capture diversity through purposive quota sampling focusing on the following categories: (1) adult participants with diagnosed hypertension in Kampot; (2) adult participants without diagnosed hypertension in Kampot; (3) adult participants with diagnosed hypertension in Phnom Penh; (4) adult participants without diagnosed hypertension in Phnom Penh. The sample frame of households with hypertensive individuals was obtained from a local non-governmental organization (NGO) providing free health consultations and support in local communities. In Phnom Penh, we also recruited postgraduate university students and civil servants working within the Ministry of Health to test if higher educational background and health literacy could be associated with differences in user experiences.

Data collection

The baseline and follow-up surveys were conducted in early 2019 by four Cambodian researchers, with training in health research methods. At product delivery, the researchers provided participants with oral and written instructions on how to use the watch and the paired application. Based on the concepts outlined in the section above and discussions with the research team, two original survey instruments were developed (Supplementary file 1). The baseline survey included questions on self-reported health status, health behaviour, and health monitoring. Participants were also asked whether they had ever used a health wearable or a mobile health application. At the end of the interview information on socio-economic status was collected to construct socio-economic tertiles, using the EquityTool questionnaire for Cambodia [15]. One month after baseline, a follow-up questionnaire was administered in the same sample of participants. The follow-up questionnaire aimed to assess to what extent and how participants had used the device, their views about its most useful features, practical issues including potential discomfort while wearing the watch or other potential barriers to continued utilisation, and willingness to pay (WTP) for the watch. Estimates of WTP were elicited using an iterative "bidding game" approach [16].

Data management and analysis

Data collected on paper forms were entered into an Excel file, and then imported into STATA version 13.1 for cleaning, processing, and statistical analysis. Descriptive statistics were used to summarize respondent characteristics at baseline and outcomes in product utilisation and acceptance in the follow-up survey. Test statistics were used to compare the demographic and socio-economic profiles of urban and rural participants. Textual information from open-ended responses was coded for frequency analysis and translated from Cambodian into English. The Kruskal–Wallis test was used to test for significant

differences in mean WTP across socioeconomic groups. Binomial regression was performed to predict utilisation of the paired smartphone application.

Results

Demographic and socio-economic characteristics

A total of 156 adult participants completed both the baseline and follow-up surveys. These included 60 hypertensive participants (30 in Phnom Penh and 30 in Kampot), 60 non-hypertensive adults (30 in Phnom Penh and 30 in Kampot), 18 civil servants and 18 postgraduate students in Phnom Penh. Only one participant at baseline (a civil servant in Phnom Penh) did not complete the follow-up survey due to watch malfunction.

Table 1 shows the demographic and socio-economic characteristics of the participants at baseline. On average, participants were aged 53.2 years (SD: 14.5; range: 22–79). In Phnom Penh, 59.8% of participants had some secondary or higher education and 52.6% were in the highest socio-economic status group. By contrast, most participants in Kampot had attended only primary school (48.3%) and were in the lowest socioeconomic group (71.7%).

These differences in socio-economic status were mirrored in the ownership of assets, including smartphones. While 77.3% of respondents in Phnom Penh owned a smartphone, only 45% in Kampot did. Of those who did not own a smartphone, the large majority (94.6%) were over 50 years of age

Health and wellbeing
Table 2 summarises findings on self-reported health status, health behaviour and self-monitoring of health and fitness. At baseline, 3.9, 30.6, 60.5 and 5.1% of the participants rated their health as "very good", "good", "fair" and "poor" respectively. Of those who rated their health as "fair" or "poor", the majority were hypertensive (46.3%) and above 50 years of age.

With respect to the behavioural questions, 85.3% of participants reported to be non-smokers, 51% said they would eat fruit or vegetables at least once a day and 48.4% do physical exercise "every week, at least once". When asked about their preventive care behaviour, 90% of hypertensive participants said they attended check-ups with a doctor, nurse or other health care provider more than once a year. However, only 46.4% of non-hypertensive participants reported regular visits and 16.2% of those older than 50 said they would never do preventive health checks. Lastly, only 10% of participants reported previous use of a smartphone fitness application and only 7% had used a health wearable before the survey – all of them in Phnom Penh and in their 20s (81.8%) or 30s (18.2%). Most hypertensive patients (61.7%) said they had never self-monitored their blood pressure at home and none of them had ever used a mobile health application or fitness watch.

Product utilisation, perceived usability and usefulness

Although health wearables were new to most participants, the technology reception was positive overall: 89.1% said they would continue using the watch and 76.9% would recommend it to either friends or relatives, while 94% said the device stimulated them to think more frequently about their health (Table 3).

Despite this positive attitude towards the device, only 34% of participants used the watch all the time during the study period, as instructed. When asked to provide further explanation, the most frequently mentioned barrier to utilisation was low battery life (n = 75/186), which lasted 3.9 days on average (SD = 2.9). Other reasons that were frequently given to explain sporadic use included watch malfunction (n = 28/186), the inconvenience of wearing the watch while taking a bath or shower (n = 36/186) and working the land (n = 19/186). A minority of participants (n = 3) also complained they were "annoyed" by the watch, while others said the display was too small. Of note, two participants reported "pain in the arm" and a "sense of tingling in the chest" after wearing the watch.

Specific features of the wearable device such as the measurement of heart rate, steps, and blood pressure were used by 89.1, 85,3 and 80.1% of participants respectively. Only 32,1% used the calories tracker (Fig. 1). In keeping with this pattern, when asked to name the most useful functions, the majority of participants (62.8%) named blood pressure measurement as the first choice, followed by heart rate monitor as the second choice (48.1%) and step counter as the third choice (19.9%). As expected, being hypertensive or older than 45 was significantly associated with a preference for blood pressure measurement. Only a minority of participants (25.6%) used the linked smartphone application; binomial logistic regression found that this outcome was strongly predicted by being a student (p = 0.000 OR = 48) or civil servant (p = 0.000 OR = 23.34).

Lastly, when asked if they had any suggestions for improvement, most participant mentioned that the watch should be more resistant to water or scratches (n = 56/123) and its battery life (n = 49/123) could be improved. A few participants suggested that cholesterol measurement (n = 2/123) and blood sugar level (n = 1/123) would be useful additional features.

Willingness to pay

The wearables were provided free of charge to all participants in our study. Nonetheless, we were interested in exploring how much people would be willing to pay for it, considering the potential marketing of a similar product as part of a public health programme. To this end, we calculated the WTP per unit, conventionally defined as the "maximum sum an individual (or a government) is willing to pay to acquire some good or service, or the maximum sum an individual (or government) is willing to pay to avoid a prospective loss" [17]. In both study locations, respondents were willing to purchase the device for an average price of 46,774 Cambodian riels (US$ 11.4 Range: US$ 2.4–48.7). However, only 60% of participants were willing to buy the product. Socioeconomic status had a statistically significant effect on mean scores of WTP (Table 4).

Discussion

This paper examined user experiences with wearable health trackers in Cambodia, contributing new insights into the reception of this technology and the wider study of mHealth in LMICs. As described, most participants had little or no experience with wearable health trackers or smartphone applications for health monitoring prior to the study, with the exception of postgraduate students in Phnom Penh. Nonetheless, the large majority of participants reported a positive experience with the device, increased health awareness and a willingness to use and recommend the device to other people after the study period. In general, participants found the health wearable useful, suggesting a similar device would be well received and could be used as a tool to monitor and control risk factors for NCDs in Cambodia, including in rural areas where access to preventive care for NCDs is limited [15].

The findings also indicate that product design and features should be tweaked to maximise technology uptake and utilisation. As we have seen, the need to charge the device was off-putting for many participants, suggesting that a self-charging battery would likely increase utilisation, particularly amongst households with limited access to electric power. Furthermore, as documented in our study and previous surveys [18], ownership of a smartphone in rural Cambodia is still low. Thus, a standalone device that can be fully operated without smartphone support would be more suitable for wide use. Lastly, a solid, waterproof design would appeal to those participants, particularly farmers, that were concerned about water damage.

Further consideration of the study findings and the study context highlights other potential challenges to technology uptake. In particular, the use of consumer health wearables is premised on an individualistic concept of care in which "digitally engaged patients" are expected to manage their own preventive health efforts [19]. Even if wearables can be designed to deliver messages and reminders based on the analysis of user data, continued use still requires a commitment to actively incorporate self-care into daily routines. In Cambodia, this may conflict with traditional culture and social norms, which emphasise the collective, social dimension of caring and disease management, particularly for the elderly. In this respect, it is worth noting that most hypertensive participants in our sample reported having regular check-ups with health providers but only a few were used to monitoring their own blood pressure.

Cost may be another important barrier to product uptake amongst poorer populations. While the average willingness to pay was high (US$ 11.4) relative to a gross national income per capita of US$ 1,530 (World Bank 2019), many participants in the lowest tertile were willing to pay only a fraction of the estimated market value (which is about US$ 30) and less than two thirds were willing to buy the watch. Thus, wide technology uptake would require some form of subsidisation or the development of a lower-cost technology, bearing in mind that participants in our study were sensitive to product design and quality. Alternatively, a public-private partnership could be devised to reduce costs and increase participation, as seen recently in Singapore [20]. In 2019, Fitbit, a leading manufacturer of consumer wearables, partnered with the government of Singapore to develop a large public health program seeking to better understand the health behaviours and lifestyles of Singapore residents using wearable technologies. Under this program, participants are given a Fitbit smartband for free, provided they consent to sharing their data with Singapore's Health Promotion Board, a government agency under the Ministry of Health which uses

collected information to carry out large studies of population health and health risks [20]. In Cambodia, a similar arrangement could be made, although adequate regulations and technical safeguards should be in place to ensure the protection of data privacy.

Lastly, any new technology is just one component of sustainable development along with other important domains such as human resources and wider infrastructure. In recent years, for example, the One Laptop per Child initiative distributed low-cost "children machines" designed to empower youth in LMICs to learn without their schools and teachers [21]. The rationale was that efforts to reform curricula in some low-income countries were too slow or expensive and teacher training was seen as of limited value due to teacher absenteeism. Nonetheless, this program was successful only in contexts where other key gaps were addressed, including sustaining school attendance by teachers and students and dissemination of course materials [22]. Similarly, health wearables alone are unlikely to have any significant impact on health outcomes in Cambodia and elsewhere. Sustainable program implementation would also require health system integration, public funding, and improvements in the quality of care, which remains a significant challenge in Cambodia [23]. In recent years, other mHealth interventions have been piloted in Cambodia including smartphones applications to deliver messages for hypertensive and diabetic patients [24], to improve newborn care awareness in rural areas [25], to remind users about available family planning methods [26], and to support community-based malaria surveillance [27]. While these programmes have generally had a positive impact on health outcomes, sustainability of donor-driven initiatives without domestic funding and full ownership has been a recurrent challenge.

Study limitations

The small sample size is a clear limitation of this study. In addition, the survey questionnaires were largely structured, with only a few open-ended questions. Therefore, we could not gain in-depth qualitative insights into individual perceptions and experiences with the given technology. This exploratory study was also carried out over a relatively short period due to time and resource constraints. As a result, we could not examine phenomena that would require a longer timeframe such as behaviour change. Finally, the study methodology relied on self-assessed measures of health status and determinants, which are prone to recall and other subjective biases [28].

Conclusions

This study provides new insights into the reception of health wearables in a low-resource context and its potential to support public health efforts to reduce the burden of NCDs. The research findings suggest that the introduction of health wearables as part of a public health programme in Cambodia could contribute to strengthening the monitoring and control of NCDs and associated risk factors, although product design, features, and costs should be adapted to the local context. As discussed, a self-charging device, water and shock resistant, which can be fully operated without smartphone support, would be appealing to a larger share of the population, especially in rural areas. Further evaluations should be conducted to provide a robust assessment of impact, comparing for example key outcomes between

users and a control group of non-users, to see if there are different outcomes in terms of risk behaviour and health seeking behaviour. Studies of health system and policy variables that may influence technology uptake would also be needed to inform programme development and implementation.

List Of Abbreviations

LMICs: low- and middle-income countries

NCDs: non-communicable diseases

NGO: non-governmental organization

WTP: willingness to pay

Declarations

Ethics approval and consent to participate

The study was approved by the National Ethics Committee for Health Research in Phnom Penh, Cambodia (157/NECHR) and the London School of Hygiene and Tropical Medicine (Ref: 15979). Information on the aims and objectives of the research project was provided to all participants and informed consent was obtained from all of them prior to being interviewed. All data were anonymized.

Consent for publication

Not applicable

Availability of data and materials

Please contact corresponding author for data requests.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

ML designed the study, analysed the data, and wrote the manuscript. PI contributed to the study design, was responsible for data collection, and reviewed the manuscript. The other authors contributed to the study design, provided critical feedback, and reviewed the manuscript. All authors read and approved the final manuscript.

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Tables

1. Demographic and socio-economic characteristics of participants

	Phnom Penh n (%)	Kampot n (%)	Totals n (%)	p value
Age group (years)[a]				0.000
< 30	23 (23.7)	-	23 (14.7)	
31-40	11 (11.3)	1 (1.7)	12 (7.7)	
41-50	4 (4.1)	7 (11.7)	11 (7.0)	
51-60	31 (32.0)	24 (40.0)	55 (35.0)	
61-70	25 (25.8)	21 (35.0)	46 (29.3)	
> 70	3 (3.1)	7 (11.7)	10 (6.4)	
Sex[b]				0.851
Female	50 (51.6)	30 (50.0)	77 (49.0)	
Male	47 (48.4)	30 (50.0)	80 (51.0)	
Education[b]				0.023
No education	13 (13.4)	6 (10.0)	19 (12.1)	
(Some) primary	26 (26.8)	29 (48.3)	55 (35.0)	
(Some) secondary and higher	58 (59.8)	25 (41.7)	83 (52.8)	
HH socio-economic status[a]				0.028
Worse off	10 (10.3)	43 (71.7)	53 (33.7)	
Middle	36 (37.1)	17 (28.3)	53 (33.7)	
Better off	51 (52.6)	-	51 (32.5)	
Own a smartphone[b]	75 (77.3)	27 (45.0)	102 (65.0)	0.000

[a] Fisher's exact test

[b] Chi square

2. Self-reported health and health seeking behaviour

	Phnom Penh n (%)	Kampot n (%)	Totals n (%)	p value
Do you smoke? [a]				0.828
No	84 (86.7)	50 (83.3)	134 (85.4)	
Occasionally	5 (5.2)	3 (5.0)	8 (5.1)	
Daily	8 (8.3)	7 (11.7)	15 (9.6)	
How would you rate your health overall? [a]				0.007
Very good	6 (6.2)	-	6 (3.8)	
Good	36 (37.1)	12 (20)	48 (30.6)	
Fair	52 (53.6)	43 (71.7)	95 (60.5)	
Poor	3 (3.1)	6 (8.3)	8 (5.1)	
How often do you do physical exercise? [b]				0.433
Never	14 (14.4)	13 (21.7)	27 (17.2)	
Occasionally	36 (37.1)	18 (30.0)	54 (34.4)	
Every week, at least once	47 (48.5)	29 (48.3)	76 (48.4)	
How often do you do checks with health care providers? [a]				0.007
Never	21 (21.7)	3 (5.0)	24 (15.3)	
Once a year	22 (22.7)	11 (18.3)	33 (21.0)	
More than once a year	53 (54.6)	46 (76.7)	99 (63.0)	
Don't know	1 (1.0)	-	1 (0.6)	
How often do you check your blood pressure at home? [a]				0.000
Never	47 (48.5)	50 (83.3)	97 (61.8)	
Rarely	9 (9.3)	-	9 (5.8)	
Regularly	38 (39.2)	10 (16.7)	48 (30.6)	
Don't know	3 (3.1)	-	3 (1.9)	
Ever used a fitness watch	11 (11.3)	-	11 (7.0)	
Ever used a mobile fitness/health app	5 (5.1)	-	5 (3.2)	

[a] Fisher's exact test

[b] Chi square

3. Utilisation and perceived usefulness of the study wearable

	Phnom Penh n (%)	Kampot n (%)	Totals n (%)	p value
How often have you used the watch in the past month? [a]				0.571
Sometimes	63 (66.0)	42 (70.0)	105 (67.3)	
Most of the time	33 (34.0)	18 (30.0)	51 (32.7)	
Do you feel this watch made you think about your health more than usual? [b]				1.000
Yes	89 (92.7)	57 (95)	146 (94.0)	
No	4 (4.2)	2 (3.3)	6 (3.9)	
Do not know	3 (3.1)	1 (1.7)	4 (2.6)	
Would you continue using this watch? [b]				0.111
Yes	82 (85.4)	57 (95.0)	139 (89.1)	
No	10 (10.4)	3 (5.0)	13 (8.3)	
Do not know	4 (4.2)	-	4 (2.6)	
Would you recommend this product? [a]				0.886
Yes	67 (77.9)	43 (75.4)	110 (76.9)	
No	12 (14.0)	8 (14.0)	20 (14.0)	
Do not know	7 (8.1)	6 (10.5)	13 (9.0)	

[a] Chi square

[b] Fisher's exact test

4. Willingness to pay for the wearable (n=93/156) by socio-economic status, Cambodian riel (US Dollar)

	Mean	SD	Median	Range	P value
Willingness to pay					0.0013 *
1 (Worse off)	35417 (8.6)	14161 (3.5)	40000 (9.8)	10000 (2.4) -70000 (17.1)	
2 (Middle)	42917 (10.5)	18053 (4.4)	40000 (9.8)	10,000 (2.4) – 80000 (19.5)	
3 (Better off)	61970 (15.1)	42388 (10.3)	50,000 (12.2)	20,000 (4.9) – 200,000 (48.7)	
Total	**46774 (11.4)**	**30330 (7.4)**	**40,000 (9.8)**	**10,000 – (2.4) 200,000 (48.7)**	

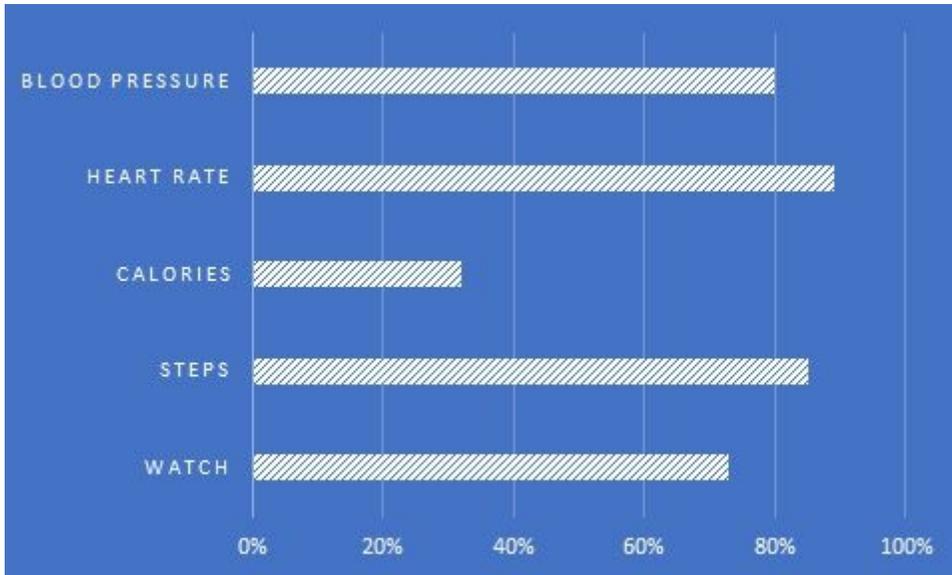* Kruskal–Wallis test (X^2 = 13.304)

Figures

Figure 1

Self-reported utilisation of the wearable by different functions

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Supplementaryfile.docx