Original Article

A Danish perspective on the use of wearables for digital monitoring

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ABSTRACT

INTRODUCTION. The digitalisation of healthcare has led to a growing use of wearable devices. These technologies enable continuous home monitoring of parameters such as heart rate, blood pressure and physical activity. While wearables have the potential to transform clinical practice and patient engagement, little is known about their real-world use in Denmark. To our knowledge, this is the first study to map the use of wearables in a combined cohort of physicians and patients in Denmark, highlighting its novelty and relevance.

METHODS. The Danish Society of Cardiology's Working Group for Digital Health & Innovation conducted a national survey among patients with heart disease, relatives, physicians and other stakeholders (n = 646) to assess current use, attitudes and perceived barriers related to wearables.

RESULTS. Use of wearables was more common among physicians (71%) than among patients (49%). Interestingly, patients and relatives reported the highest sense of security with the technology – even without active use. Patients valued wearables for self-monitoring and improved access to care, whereas physicians expressed greater skepticism, particularly regarding data quality and clinical utility.

CONCLUSIONS. These findings highlight a need for clear guidelines, structured data integration and greater user involvement. Aligning expectations between patients and clinicians will be essential for broader adoption. Addressing concerns about clinical relevance, establishing shared understanding and supporting integration into care workflows are key steps forward.

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Citizens' satisfaction with the rapid digitalisation of society, including healthcare [1], is reflected in the growing use of wearable devices. Wearables continuously collect large amounts of real-time health data, such as heart rhythm, sleep and physical activity, offering an unprecedented view of users' physical condition over time. Depending on the purpose, different types of wearables have been developed – smart rings, watches and fitness trackers – and the definition continues to expand with new sensor technologies. Smartwatches are currently the most widely used wearable for private, clinical and research purposes. Studies, including the Apple Heart Study [2] and the Fitbit Heart Study [3], have reported >80% accuracy in detecting atrial fibrillation using wearables, based on data from >400,000 adults. The vast amounts of continuous data collected by wearables have the potential to revolutionise both clinical and research practice. The need for this became clear during the COVID-19 pandemic, which highlighted the urgent need to develop new digital solutions in healthcare that allowed clinicians to monitor and interact with patients without physical contact. Such use cases have prompted

innovative solutions for developing and implementing a digital health infrastructure that supports the adoption of these technologies by citizens and clinicians, including wearables [4].

In Denmark – often referred to as one of the most digitalised countries globally – the potential is considerable. National digital infrastructure already supports citizen- and clinician-based use, and the next major step is to bring healthcare closer to citizens through home-based care and digital solutions, potentially improving efficiency while reducing costs [4].

For citizens, wearables should intuitively provide a greater sense of control over their health and well-being. However, some patients express concerns about how safe they feel using these devices. Some may struggle to trust the data or feel uncertain about the technology, especially when they encounter difficulties interpreting the results. Moreover, clinicians' attitudes toward the use of wearables are often unclear, making it difficult to assess whether the technology is being effectively and reliably integrated into clinical practice.

Despite Denmark's robust digital infrastructure and the rapid expansion of wearable technologies, the understanding of their actual use and perception among citizens and clinicians remains limited. To address this, the DCS Working Group "Digital Health & Innovation" examined stakeholder attitudes, practical applications and perceived clinical relevance of wearables, as well as barriers to their integration into healthcare.

Methods

To examine the use of wearables, a questionnaire in Danish was distributed to a diverse group of individuals, including patients with heart disease, relatives, physicians and industry employees (others). This population was selected to represent key stakeholders in the use and implementation of wearable health technologies in Denmark. Patients with heart disease may benefit more than other groups from continuous monitoring, supported by relatives involved in their care and technology adoption. Physicians provided the clinical perspective on integration into practice, while industry respondents reflected the technological and developmental drivers. In conjunction, these groups offer a broad yet focused view of those most direct stakeholders in wearable health solutions.

The questionnaire (see Supplementary material) consisted of two parts: 1) general questions about personal use and awareness of wearables, and 2) a section for healthcare professionals focused on the use of wearables in a clinical context. The general survey was distributed to members of the Danish Heart Foundation's user panel (n = 600) and to members of the Danish Society of Cardiology (n = 1,391) via email with a link and a QR code. There were no formal inclusion or exclusion criteria beyond membership of the relevant societies. Members from *Hjerteforeningen* (both patients and physicians) and the Danish Society of Cardiology were invited to participate. As some individuals could be members of both organisations, this was considered the sole exclusion criterion. As a result, calculating a true response rate for the survey was not possible. The final dataset was checked for obvious duplicate entries from the same respondent. All data were handled in accordance with the General Data Protection Regulation (GDPR) and were pseudo-anonymised, ensuring that responders could not be identified.

Exposure groups

We evaluated the use of wearables and whether they were perceived as enhancing a sense of security. Respondents were grouped by background into healthcare professionals (n = 179) and patients with heart disease, their relatives, and other related groups (n = 467). In addition, respondents were classified based on wearable use into users (n = 462) and non-users (n = 178).

Statistics

All categorical variables from the questionnaire are reported as frequencies and percentages. Continuous variables are reported as medians with 25th-75th percentiles. We calculated 95% CI using the Wilson Score method, which provides greater accuracy than the Wald approach for small samples or proportions near 0 or 1. Comparative analyses used the Wilcoxon rank-sum test for continuous variables and Pearson's χ^2 test for categorical variables. For analyses of perceived security, responses were dichotomised into "high/very high" versus "low/some" sense of security. Participants with missing or "Do not know" responses were excluded (n = 40 wearable users; n = 78 non-users). All data processing and figures were generated using SAS Enterprise software version 8.4 (SAS Institute Inc., Cary, North Carolina, USA).

Trial registration: not relevant.

Results

A total of 646 individuals responded, of whom 179 (27.8%) identified as physicians, 423 (65.5%) as heart patients, 31 (4.8%) as relatives and 13 (2.0%) as falling outside these categories. Respondents had a median age of 67 years (55-75 years), and 265 (41.0%) were women.

One or more forms of home monitoring of health data were used by 462 (71.5%) respondents, including 126 (27%) physicians and 336 (73%) who were not physicians (patients, relatives or other backgrounds). Among these, the use of blood pressure monitors, smartwatches and smartphones was relatively evenly distributed, as shown in **Figure 1**. Smartwatches were most frequently used among the younger segment of the patient population, particularly among patients under 50 years of age, whereas the use of smartphones and blood pressure monitoring was more evenly distributed across age groups (**Figure 2**).

FIGURE 1 Distribution of wearable types among users. Percentage distribution of wearable types among respondents who reported using wearables (n = 462). Note that respondents could report using more than one type of wearable, which means the total percentage exceeds 100.
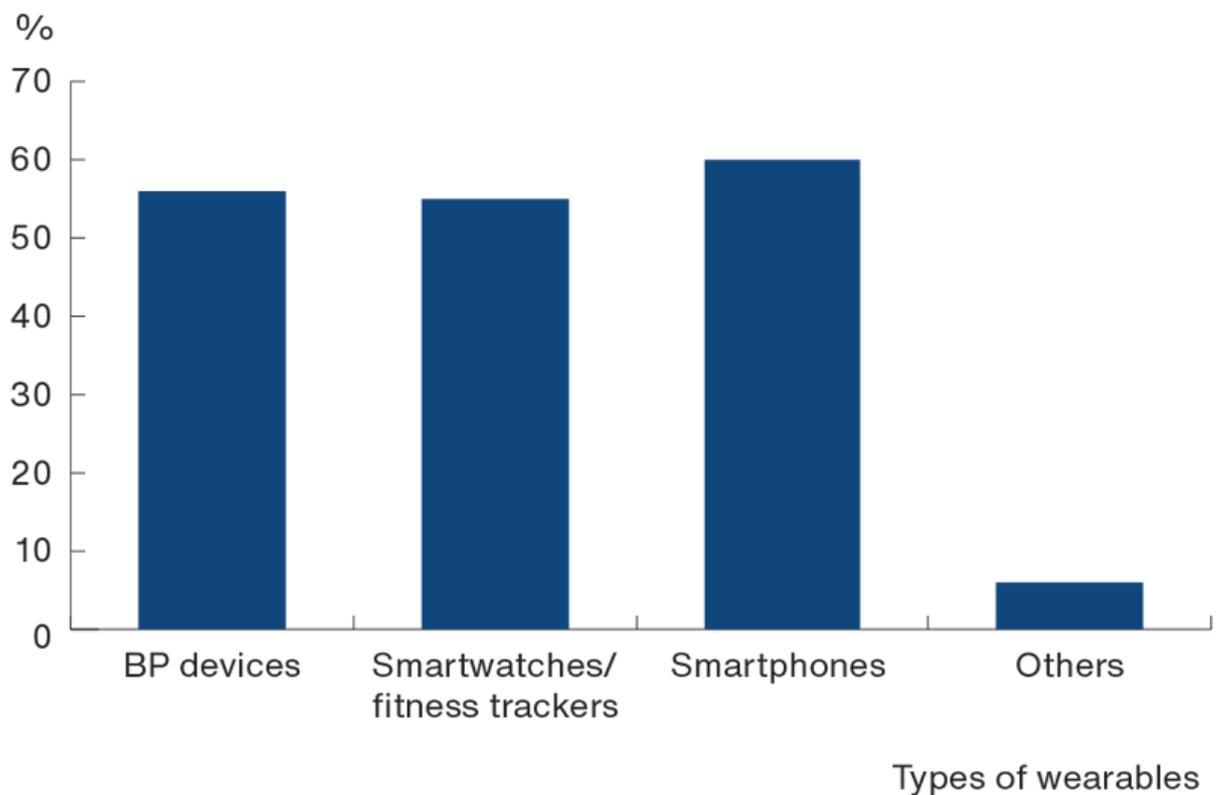
BP = blood pressure.

FIGURE 2 Age distribution among patients and relatives. The percentage of patients and relatives using specific types of wearables or not using wearables, stratified by age group. For each wearable type or the group of non-users, the total sum across age groups adds up to 100%. A total of 20 respondents were excluded from this figure due to missing information on either age or wearable type.
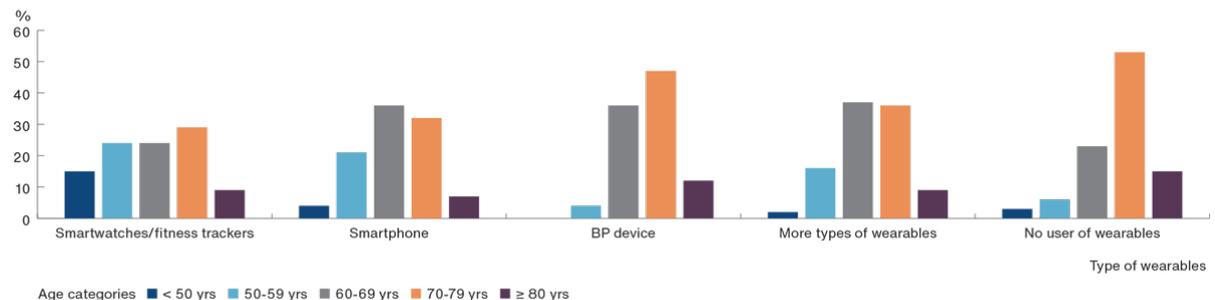

BP = blood pressure.

Wearables were used by 71% (95% CI: 63-79%) of physicians, compared with 49% (95% CI: 44-55%; p < 0.001) of

patients. The distribution by group is shown in detail in **Figure 3** A. Respondents with a medical background were significantly younger, with a median age of 45 years (35-60 years) compared with 72 years (62-76 years) for patients and relatives (p < 0.001; Figure 3B).

FIGURE 3 Age distribution by user group (clinicians versus patients and others). **A.** Percentage distribution of smartwatch users (n = 462), including both smartwatches and fitness trackers, by background group (clinicians, patients and relatives). **B.** Histogram showing the age distribution of respondents. The y-axis shows the number of individuals at each age, and the x-axis shows age ranging from 20 to 100 years. The median age among clinicians was 46 years, and the median age among patients and relatives was 70 years. Eight respondents with missing age information were excluded from this figure.
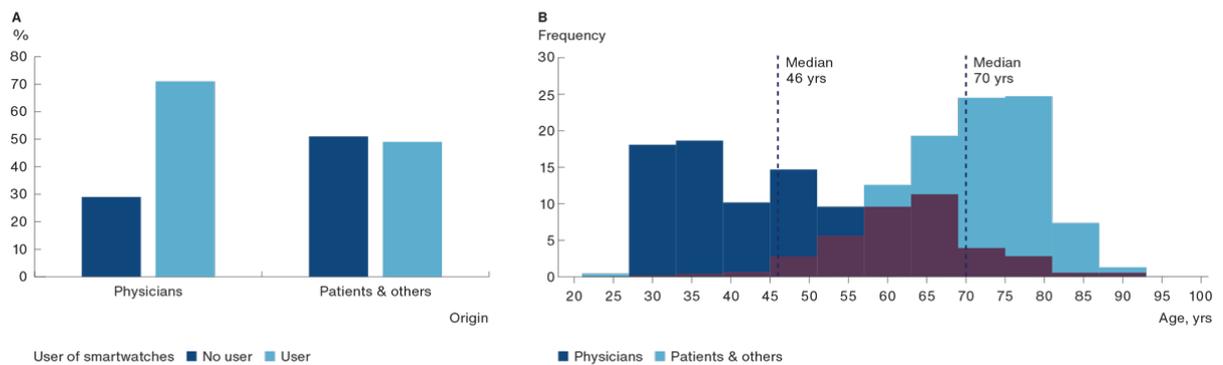
Sense of security

Respondents were also asked to what extent they perceived wearables as providing a sense of security. The results showed that patients and relatives were more likely to find wearables reassuring than those with a medical background, regardless of whether wearables were used (**Figure 4**). Among participants who used wearables, a higher proportion of patients with heart disease or relatives felt a higher sense of security using wearables (44% (95% CI: 39-50%)) than healthcare professionals (22% (95% CI: 14-28%), p < 0.001). Evaluating those who did not use wearables, similar results were observed (33% (95% CI: 23-46%) versus 10% (95% CI: 4-23%), p < 0.001, respectively).

FIGURE 4 Perceived sense of security with wearables. **A**. Percentage of respondents, categorised by background, who reported to what extent they perceive that wearables provide a sense of security. A includes only respondents who use wearables (n = 462). Ten respondents with missing information on perceived security were excluded.
B. The percentage of respondents, categorised by background, who reported the extent to which they perceive that wearables provide a sense of security. B includes only respondents who did *not* use wearables (n = 167).
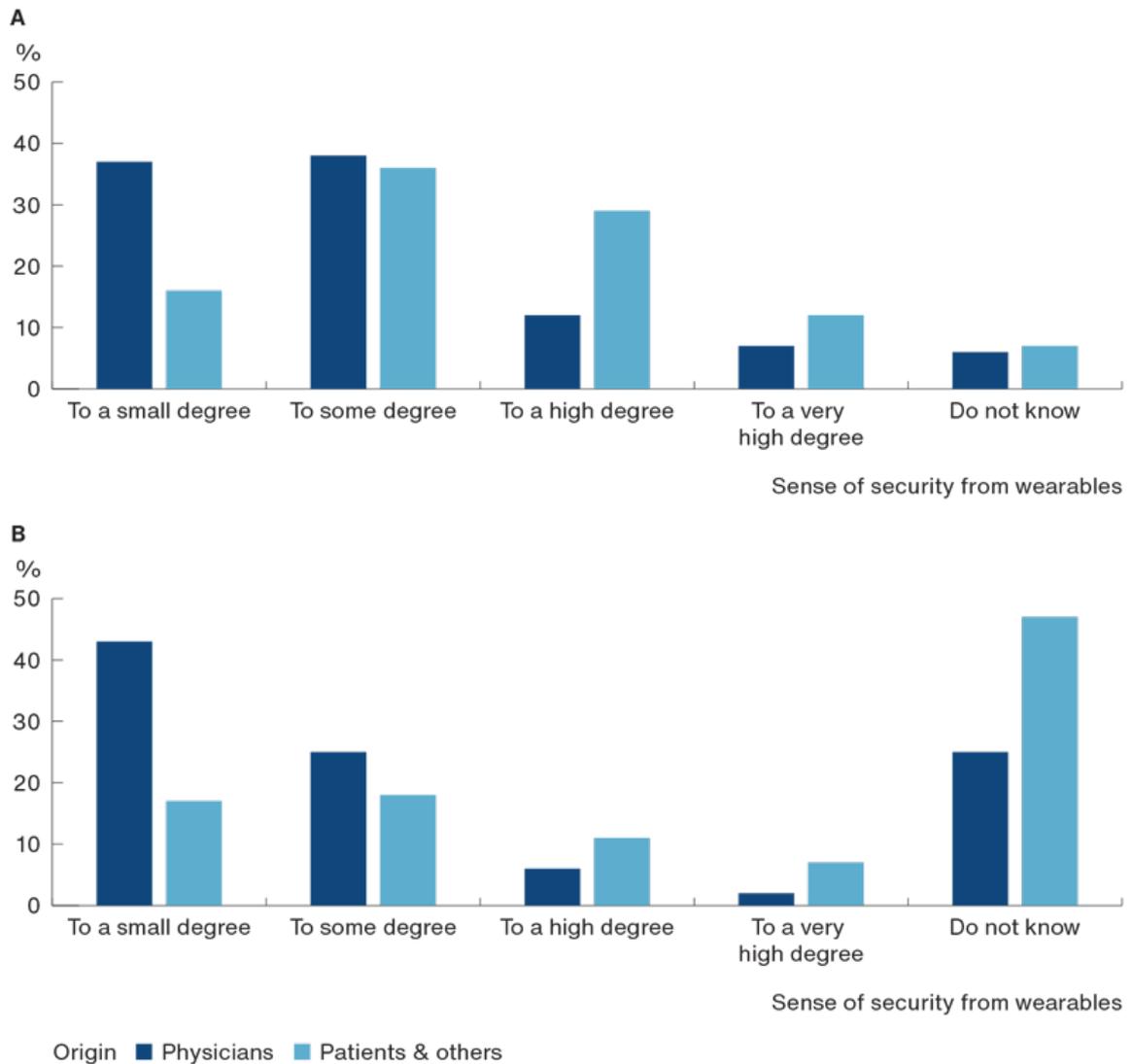
Discussion

This survey of 646 respondents, of whom nearly half were women, examined the use of and attitudes toward wearables. It provides insight into perceived practical and psychological factors associated with the use of an emerging technology. 72% of participants used some form of home monitoring, which supports Denmark's position as a highly digitalised country in healthcare. The types of wearables used were primarily smartphones, home blood pressure monitors and smartwatches – with the latter being more common among healthcare professionals (71%) than among patients with heart disease (49%).

The fact that nearly two-thirds of respondents actively used some form of home monitoring supports the view that digital health technology is not merely a future prospect but is already becoming an integral part of healthcare, for both patients and professionals.

Age and usage

Despite their comparatively higher median age, patients felt more reassured by wearables than physicians, suggesting differing perceptions of the technology's potential and ease of use. One possible explanation is that patients see wearables as tools for self-monitoring that provide a sense of control over their health, and they may not have the same level of insight into the current evidence of benefit versus risk as physicians [5]. For many patients, especially older ones, this sense of autonomy may be a strong motivator for adopting the technology – particularly if it is perceived as a simple and accessible way to track one's health. At the same time, barriers for elderly users, such as digital literacy, usability challenges and limited access to devices, need to be considered to ensure equal participation and avoid digital exclusion [6, 7].

Despite skepticism, physicians are monitoring more

Home monitoring use was higher among physicians themselves than among others, indicating a disconnect between personal use and the clinical integration of wearables. Notably, although the use of wearables and home monitoring was generally high, the specific technologies (blood pressure monitors, smartwatches and smartphones) were used in a relatively even manner across users.

One explanation for the discrepancy in data use patterns between health professionals and citizens may be that physicians place higher demands on data reliability and validity in clinical care than in personal use. Concerns about data accuracy and the limited linkage between symptoms and self-monitored health data likely contribute to this hesitancy. This skepticism should be viewed in the context of traditionally rigid outpatient diagnostic pathways, now being challenged by a rapidly evolving digital landscape. It reflects broader concerns about integrating technology into clinical practice, including the need for data validation and appropriate incorporation into treatment algorithms [6].

Larger, well-designed studies are needed to convince physicians of the clinical value of wearables. Evidence remains limited, and proof of efficient workflow integration is lacking. Successful implementation requires clinical validation and practical demonstration of how wearable data can be embedded into care pathways through electronic healthcare records [7].

Digital therapeutics: opportunities and challenges of wearables

Wearable and home-monitoring technologies offer major opportunities within digital therapeutics, with the potential to transform patient care and improve healthcare efficiency. Devices that measure, for example, heart rhythm, blood pressure, sleep and activity provide real-time data that enable remote monitoring and data-driven treatment decisions. Targeted digital interventions may improve outcomes, prevent complications and allow for early intervention, particularly for chronic conditions such as cardiovascular disease, diabetes or COPD [8-10]. Continuous access to patient-generated data also supports individualised treatment tailored to each patient's needs and responses over time.

A key advantage of wearable-supported digital therapeutics is their ability to overcome geographical and temporal barriers. Integrating wearable data into electronic health records enables clinicians to monitor and interact with more patients simultaneously, increasing capacity while reducing workload [11]. This supports a more flexible, personalised approach to care, with tailored follow-up when needed and fewer in-person consultations.

However, implementing wearables requires close collaboration between patients and healthcare professionals to ensure accurate and effective use. Patients need guidance in operating their devices, and clinicians must be able to trust the data, which depends on high measurement quality. Digital inclusion is equally important, as effective use requires both groups to have the necessary knowledge and access to devices and platforms. This is often a challenge for older adults or those with limited digital skills. The cost of wearables, especially when worn by patients, may also pose a barrier, emphasising the need for healthcare support to ensure equitable access to digital care pathways.

Furthermore, the wider use of wearables and digital screening may substantially increase the number of findings requiring follow-up, placing additional demands on healthcare resources if systems are not prepared to handle the influx of data and potential new cases. Although wearables are often promoted as tools to enhance efficiency and reduce workload, current evidence for these benefits remains limited. Moreover, while wearable-based screening increases the detection of previously undiagnosed atrial fibrillation (AF) and leads to more frequent initiation of anticoagulant therapy, it remains uncertain whether management of screen-detected, often asymptomatic and short-lasting AF results in improved patient outcomes [12].

Conclusions

Among physicians and, primarily, patients with heart disease and their relatives, there is a high use of wearable technology, but also notable challenges regarding acceptance and trust. This is the first Danish survey to compare perspectives among physicians, patients and relatives, underscoring the novelty of these findings. The digital transformation of healthcare requires sustained attention to technological and human factors to ensure that clinicians and patients can realise the full potential of wearables.

To realise the benefits of wearables, close collaboration between healthcare professionals and patients is essential, with both parties confident in using the technology and having the necessary resources and knowledge to implement it effectively. Future initiatives should balance patient enthusiasm with physician caution, strengthen education, improve digital inclusion and develop a clearer understanding of the role of technology in both clinical practice and patient self-monitoring.

Limitations

Our survey included only patients and physicians involved in cardiology, resulting in a small, selected sample and limited generalisability. Selection bias may have occurred if respondents were more interested in digital health or more engaged in their care, potentially introducing information bias. As a cross-sectional study, it reflects perceptions at a single point in time and cannot determine temporal or causal relationships.

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earlier survey on the use of wearables in Denmark, which has served as an important inspiration and foundation for the continued work of the DCS Working Group on Digital Health & Innovation

REFERENCES

1. Ritzau. Borgerne giver sundhed.dk topkarakter for andet år i træk. https://via.ritzau.dk/pressemeddelelse/13754951/borgerne-giver-sundheddk-topkarakter-for-andet-ar-i-traek?publisherId=10524793&lang=da (Feb 2026)

2. Perez MV, Mahaffey KW, Hedlin H, et al. Large-scale assessment of a smartwatch to identify atrial fibrillation. N Engl J Med. 2019;381(20):1909-1917. https://doi.org/10.1056/NEJMoa1901183

3. Lubitz SA, Faranesh AZ, Atlas SJ, et al. Rationale and design of a large population study to validate software for the assessment of atrial fibrillation from data acquired by a consumer tracker or smartwatch: The Fitbit Heart Study. Am Heart J. 2021;238:16-26. https://doi.org/10.1016/j.ahj.2021.04.003

4. Healthcare Denmark. Digitalisation. Healthcare Denmark, 2024. https://healthcaredenmark.dk/national-strongholds/digitalisation (Feb 2026)

5. Imeraj A, Pihl A, Jakobsen PR, et al. Clinical applications of smartwatches. Ugeskr Læger. 2022;184:V03210225

6. Shi Z, Du X, Li J, et al. Factors influencing digital health literacy among older adults: a scoping review. Front Public Health. 2024;12:1447747. https://doi.org/10.3389/fpubh.2024.1447747

7. Wang Y, Wu Z, Duan L, et al. Digital exclusion and cognitive impairment in older people: findings from five longitudinal studies. BMC Geriatr. 2024;24(1):406. https://doi.org/10.1186/s12877-024-05026-w

8. Kunkel JB, Graversen PL, Andersen MØ, Jensen MT. Wearables er det nye sort, men følger de hvide kitler med? Ugeskr Læger. 7. feb 2024. ugeskriftet.dk/debat/wearables-er-det-nye-sort-men-folger-de-hvide-kitler-med (Feb 2026)

9. Mattison G, Canfell O, Forrester D, et al. The influence of wearables on health care outcomes in chronic disease: systematic review. J Med Internet Res. 2022;24(7):e36690. https://doi.org/10.2196/36690

10. Evensen SN. Effect of wearable activity trackers on physical activity levels in obese- and overweight individuals during a rehabilitation process. Thesis. NTNU, 2020. https://nva.sikt.no/registration/0198ed2c95bb-0fdce94d-7770-44bf-a4d5-8d2a458ecb1a (Feb 2026)

11. Rodriguez-Leon C, Villalonga C, Munoz-Torres M, et al. Mobile and wearable technology for the monitoring of diabetes-related parameters: systematic review. JMIR Mhealth Uhealth. 2021;9(6):e25138. https://doi.org/10.2196/25138

12. Wahab A, Nadarajah R, Larvin H, et al. Systematic screening for atrial fibrillation with non-invasive devices: a systematic review and meta-analysis. Lancet Reg Health Eur. 2025;53:101298. https://doi.org/10.1016/j.lanepe.2025.101298