

# Mobile/wearable digital devices for care of active cancer patients: a survey from the ESC Council of Cardio-Oncology

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Received 11 July 2024; revised 30 September 2024; accepted 14 October 2024; online publish-ahead-of-print 21 January 2025

## Aims

The Council of Cardio-Oncology of the European Society of Cardiology developed an on-line anonymous survey to provide an overall picture of the current practice on the use of mobile and wearable digital devices in cardio-oncology and the potential barriers to their large-scale applicability.

## Methods and results

Between June 2023 and January 2024, an online anonymous questionnaire was completed by 220 healthcare professionals from 55 countries. The greatest number of respondents reported that mobile/wearable digital devices have a role in all active cancer patients for measuring heart rate (33.9%), blood pressure (34.4%), body temperature (32.0%), physical activity (42.4%), and sleep (31.2%). In the setting of atrial fibrillation detection, respondents were evenly split between applying these technologies in all patients (33.0%) or only in selected patients (33.0%). Regarding QTc interval monitoring, 30.6% reported that mobile/wearable digital devices play a role only in selected patients. The decision to use the device was taken by the patient in 56.6% of cases and the physician in 43.4%. The most important barrier reported to mobile/wearable device implementation in the setting of cardiac rhythm monitoring and QTc measurement was their cost (weighted average: 3.38 and 3.39, respectively).

## Conclusion

Mobile/wearable digital devices are considered to play an important role in different settings of cardio-oncology, including monitoring of patients' parameters and arrhythmia detection. Their role in monitoring physical activity and QTc interval appears more nuanced. The most important perceived barrier to mobile/wearable digital device implementation is considered their high cost.

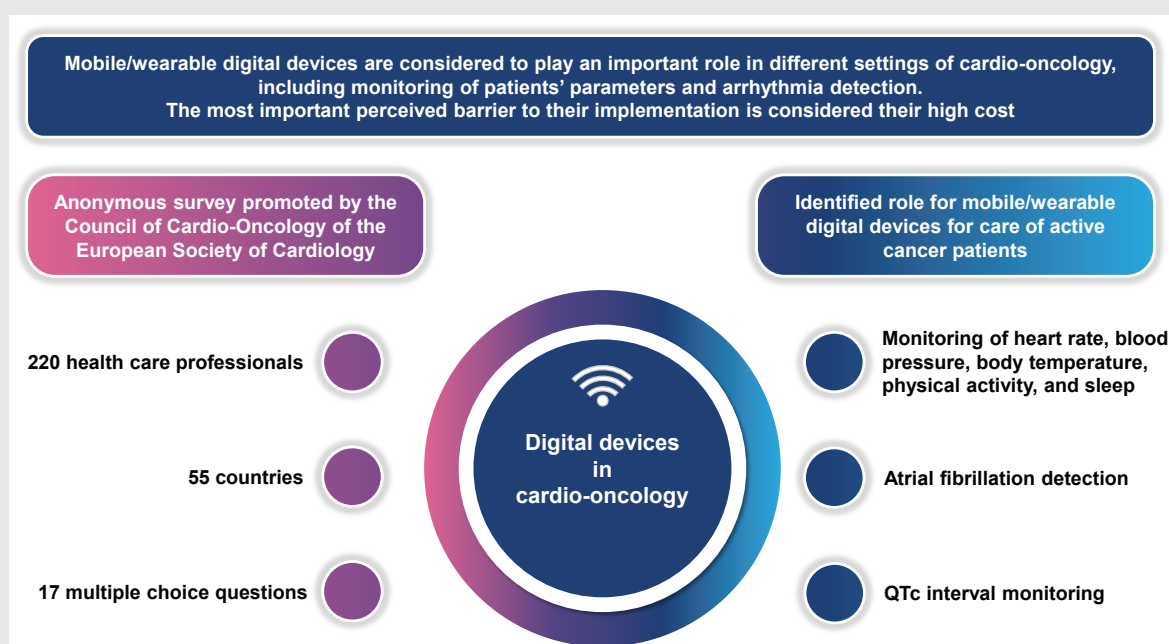
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## Graphical Abstract



## Keywords

Atrial fibrillation • Arrhythmias • Cardio-oncology • Digital health • mHealth • Wearable devices

## Introduction

Cardio-oncology is a relatively new discipline with rapidly growing interest and importance. This reflects the increasing number of cancer treatments with cardiovascular toxicity, increasing cancer patient numbers with the ageing population, growing awareness, and the bidirectional relationship linking cancer and cardiovascular diseases (CVDs) including their shared risk factors. The aim of cardio-oncology services is to improve cancer patient care and cardiovascular outcomes before, during, and after cancer treatments.<sup>1,2</sup> Cancer survivor numbers are expected to increase in the next years, and those with CVD will increase as well.<sup>3–6</sup>

A recent study<sup>5</sup> showed that the presence of severe comorbidities nearly doubled in cancer survivors aged  $\geq 85$  years when compared with those aged 66–69 years. Heart failure (HF), chronic obstructive pulmonary disease, and diabetes were the three most prevalent comorbidities observed. More effective cancer therapies prompted a steady decline in cancer-related mortality, paralleled by an increase in CVD-related mortality in survivors, which is currently their leading cause of non-cancer death.<sup>7,8</sup> Thus, as the relative weight of cancer in determining patient outcome decreases, the relative role of CVDs increases.

Physicians aim to provide a holistic and integrated approach to patient care, aiming at tackling not only the cancer itself but also to manage comorbidities, thus improving outcomes.<sup>9</sup> Mobile/wearable digital devices can be used to monitor different clinical parameters, including vital signs and physical activity, which can be used for early recognition of changes in patients' clinical status and for personalized delivery of treatments.<sup>10</sup> Moreover, the utilization of mobile/wearable digital devices mitigates the issue of in-person consultations, particularly pertinent to patients facing mobility limitations. This challenge has been exacerbated by the COVID-19 pandemic,<sup>11</sup> which had a dramatic impact on healthcare provision and limited the access to healthcare.<sup>12,13</sup> Despite several potential advantages, mobile/wearable digital devices

are still not widely employed, due to multiple barriers to their use, including high costs and lack of digital literacy.<sup>14–16</sup>

The Council of Cardio-Oncology of the European Society of Cardiology developed an on-line anonymous survey to provide an overall picture of the current practice on the use of mobile and wearable digital devices in cardio-oncology and the potential barriers to their large-scale applicability, with a focus on patients with active cancer.

## Methods

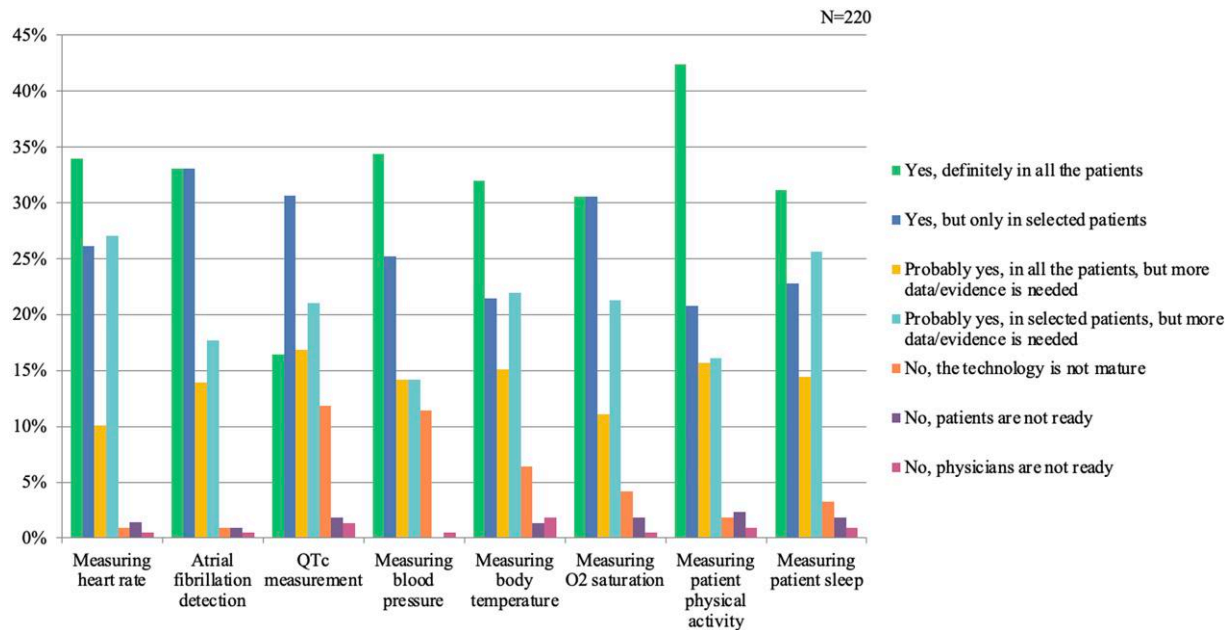
Between June 2023 and January 2024, an online anonymous questionnaire was distributed to the network healthcare professionals working in the field of cardio-oncology and arrhythmias using the European Society of Cardiology infrastructure, website, social media platforms, and e-mail. Individuals were directly engaged through emails and interactions via the online channels. Participating countries were not restricted to Europe, and there were no restrictions on potential respondents to the survey. The questionnaire consisted of 17 multiple choice questions. Some questions permitted only a single answer, while others allowed for multiple responses (see [Supplementary material online, Appendix](#)). No answer was mandatory to complete the survey. Therefore, for the purpose of the present analysis, missing data were excluded. The survey complied with the European General Data Protection Regulation.

Survey Monkey® was used for the online questionnaire.

Counts and percentage or weighted means are reported for each answer of the survey. Statistical analyses and graphics were performed using Microsoft Excel (Version 16.71).

## Results

A total of 220 participants from 55 countries completed the survey (see [Supplementary material online, Table S1](#)). A total of 61.3% of



**Figure 1** Grading of the role of mobile/wearable digital devices in active cancer patient care.

respondents were male, and the majority were aged 40–65 years (see [Supplementary material online, Figure S1](#)). Participating centres included academic university hospitals (54.1%), public hospitals (25.7%), private hospitals (11.9%), outpatient clinics (5.5%), and other institutions (2.8%). The respondents' number of years in clinical practice at consultant level is highlighted in [Supplementary material online, Figure S2](#), with 42.6% having  $\geq 20$  years of experience. The respondents came from a wide range of subspecialty backgrounds, including cardio-oncology (39.2%), general cardiology (16.1%), electrophysiology (16.1%), HF (8.3%), cardiac imaging (6.0%), interventional cardiology (3.2%), haematology (2.8%), oncology (0.9%), internal medicine (1.8%), geriatrics (0.5%), and also nurses (1.4%), general practitioners (0.5%), and others (3.2%; see [Supplementary material online, Figure S3](#)).

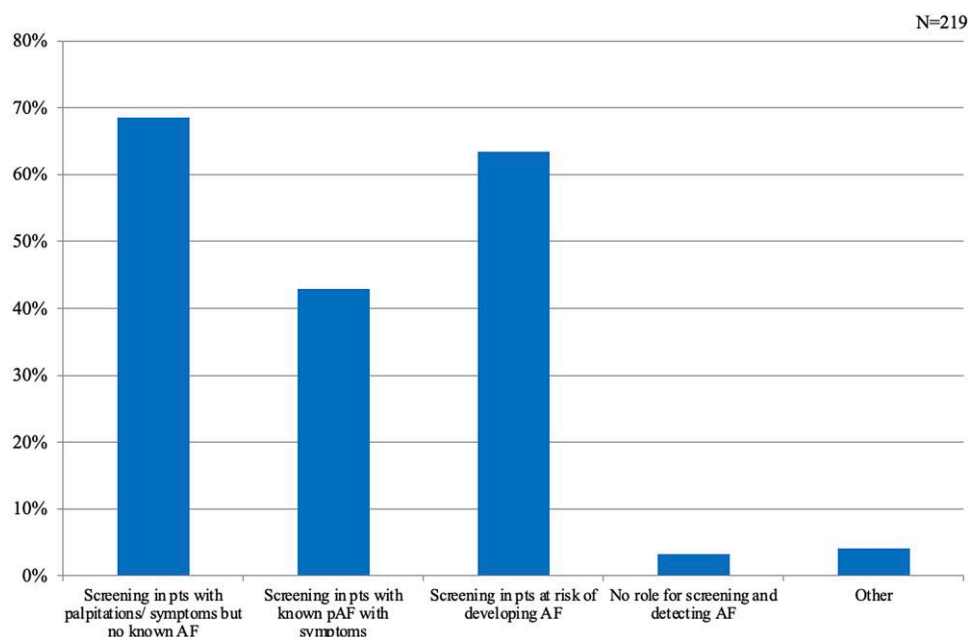
## Role of mobile/wearable digital devices and setting of use in cardio-oncology

As shown in [Figure 1](#), participants were asked to report, according to their view, the role of mobile/wearable digital devices in eight different scenarios. The majority of respondents reported that mobile/wearable digital devices have a role in all patients for measuring heart rate (33.9%), blood pressure (34.4%), body temperature (32.0%), physical activity (42.4%), and sleep (31.2%). Regarding atrial fibrillation (AF) detection and oxygen saturation measurement, the majority was evenly split between applying these technologies in all patients (33.0 and 30.6%, respectively) and only in selected patients (33.0 and 30.6%, respectively). For QTc interval measurements, the greatest number of respondents (30.6%) reported that mobile/wearable digital devices play a role only in selected patients. Between 0.9 and 11.9% of participants reported for all the previous settings that the technology is not mature, patients are not ready (0.0–2.3%), or physicians are not ready (0.5–1.8%) for using wearable/digital tools. These data did not substantially differ when comparing cardio-oncologists with other specialists (see [Supplementary material online, Table S2](#)).

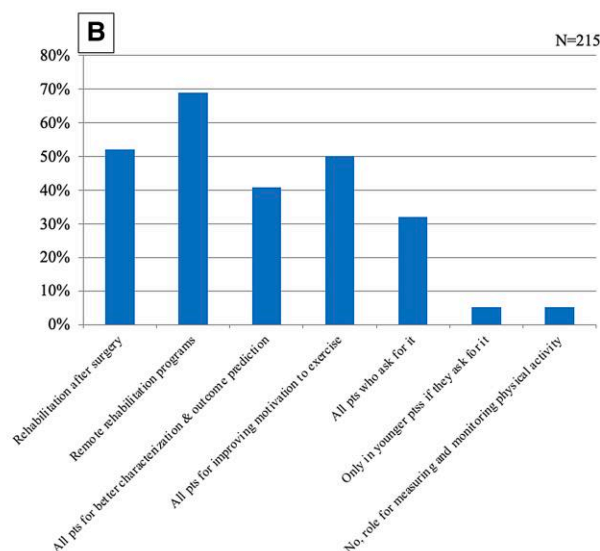
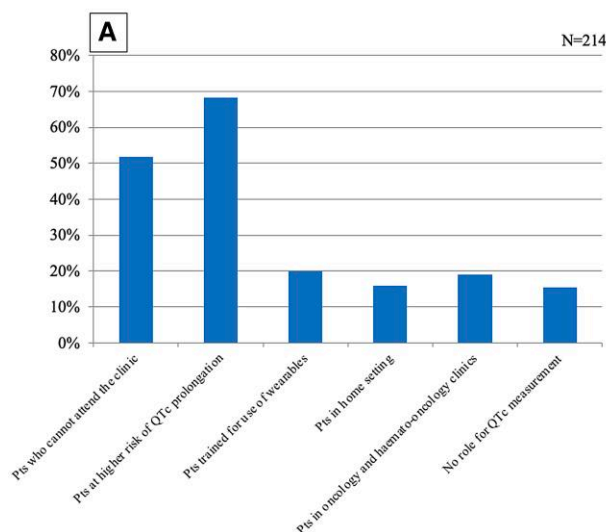
Regarding AF detection in patients with active cancer, 68.5% of respondents reported that mobile/wearable digital devices have an important role for AF screening in patients with palpitations or other symptoms who have no prior history of AF, 63.5% reported that these devices have a role for AF screening in patients at risk of developing the arrhythmia, and 42.9% for AF screening in patients with known paroxysmal AF with symptoms. Conversely, only 3.2% of respondents reported that they do not think that these devices may have an important role for screening and detecting AF in cancer patients ([Figure 2](#)). Answers of cardio-oncologist when compared with other specialists are reported in [Supplementary material online, Table S3](#).

A total of 51.9% of respondents reported that mobile/wearable digital devices have an important role for QTc interval measurement in patients with active cancer who cannot attend the clinic, 68.2% for increasing the frequency of QTc measurement in patients at higher risk of QTc prolongation, 20.1% for routine QTc measurement in patients trained for using wearables, 15.9% for routine QTc measurement in patients at home, 19.2% for routine QTc measurement in patients in oncology and haemato-oncology clinics, while 15.4% reported that they do not think that these devices have a role for QTc measurement ([Figure 3A](#)). Answers of cardio-oncologist when compared with other specialists are reported in [Supplementary material online, Table S4](#).

Regarding measurement and monitoring of physical activity in patients with cancer, 52.1% of respondents reported that mobile/wearable digital devices may have a role for patients who need rehabilitation after surgery, 68.8% for remote cardio-oncology rehabilitation programmes, 40.9% for all patients for improving their characterization and outcome prediction, 50.2% for all patients for improving motivation to exercise, 32.1% for all patients who specifically ask for it, 5.1% only in younger patients if they specifically ask for it, and 5.1% reported that they do not think that use of mobile/wearable digital devices has a role for measuring and monitoring physical activity ([Figure 3B](#)). Answers of cardio-oncologist when compared with other specialists are reported in [Supplementary material online, Table S5](#).



**Figure 2** Settings where mobile/wearable digital devices may have an important role with regard to atrial fibrillation detection in patients with active cancer. AF, atrial fibrillation; pAF paroxysmal atrial fibrillation; pts, patients.

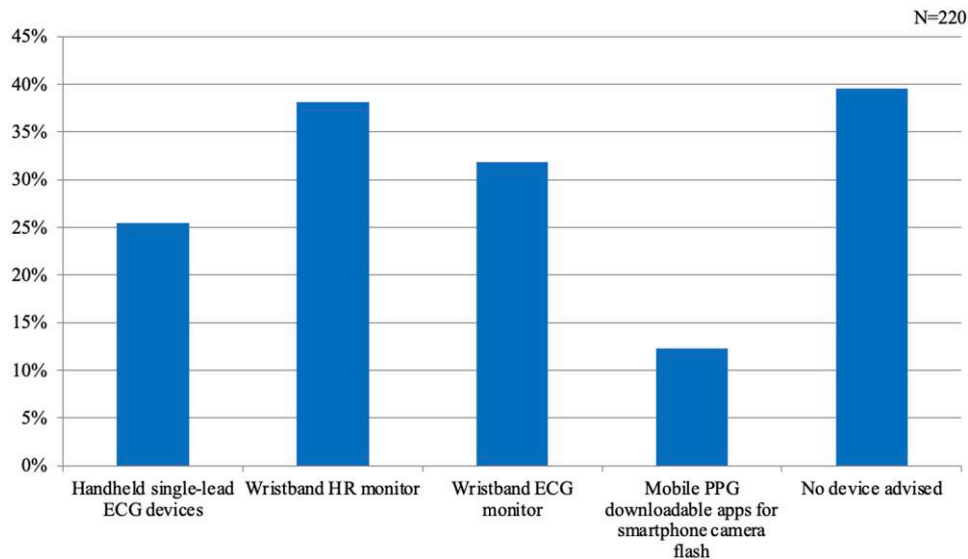


**Figure 3** Settings where mobile/wearable digital devices may have a role in patients with active cancer with regard to QTc interval measurement (A) or physical activity monitoring (B). pts, patients.

## Type of mobile/wearable devices for heart rhythm identification and atrial fibrillation detection

A significant proportion of respondents (39.6%) reported that they do not advise the use of any mobile/wearable devices for checking

the cardiac rhythm and detecting AF. Among devices, wristband heart rate monitors were the most commonly advised (38.2%), followed by wristband electrocardiogram (ECG) monitors (31.8%), handheld single-lead ECG devices (25.5%), and mobile photoplethysmography downloadable apps for smartphone camera (12.3%; [Figure 4](#)).



**Figure 4** Type of device advised to active cancer patients for heart rhythm identification and atrial fibrillation detection. HR, heart rhythm; PPG, photoplethysmography.

## Target population and use

Checks for suspected AF or other arrhythmias detected using wearable devices/apps are performed every week by 19.1% of respondents, 1–2 times in a month by 23.2%, once every 6 months by 26.8%, and once in a year by 1.8%. A total of 29.1% of respondents reported that they never look after active cancer patients with suspected AF or other arrhythmias detected using wearable devices/apps. In case of potential AF detected through wearable devices, the decision to use the device was taken by the patient in 56.6% of cases and the physician in 43.4%. Finally, the age distribution of the patients asking about the use of wearable devices to measure cardiac rhythm and detect arrhythmias was between 55 and 65 years in 26.3%, between 41 and 55 years in 23.3%, between 65 and 75 years in 20.4%, ≤40 years in 19%, and above 75 years in 11% on average ([Supplementary material online, Figure S4](#)).

## Barriers to implementation of mobile/wearable devices

The most important barriers reported for implementation of mobile/wearable devices for cardiac rhythm check and AF detection in patients with active cancer were as follows: high costs (weighted average: 3.38) and low digital literacy (3.13), but also lack of reimbursement (2.92), high complexity to provide service (2.87), and lastly lack of evidence of clinical benefit (2.69) were reported ([Figure 5A](#)). The barriers reported for implementation of mobile/wearable devices for QTc measurement were, in descending order, high costs (weighted average: 3.39), lack of evidence of clinical benefit (3.08), high complexity to provide service (3.05), followed by low digital literacy (2.82) and lack of reimbursement (2.66; [Figure 5B](#)).

## Discussion

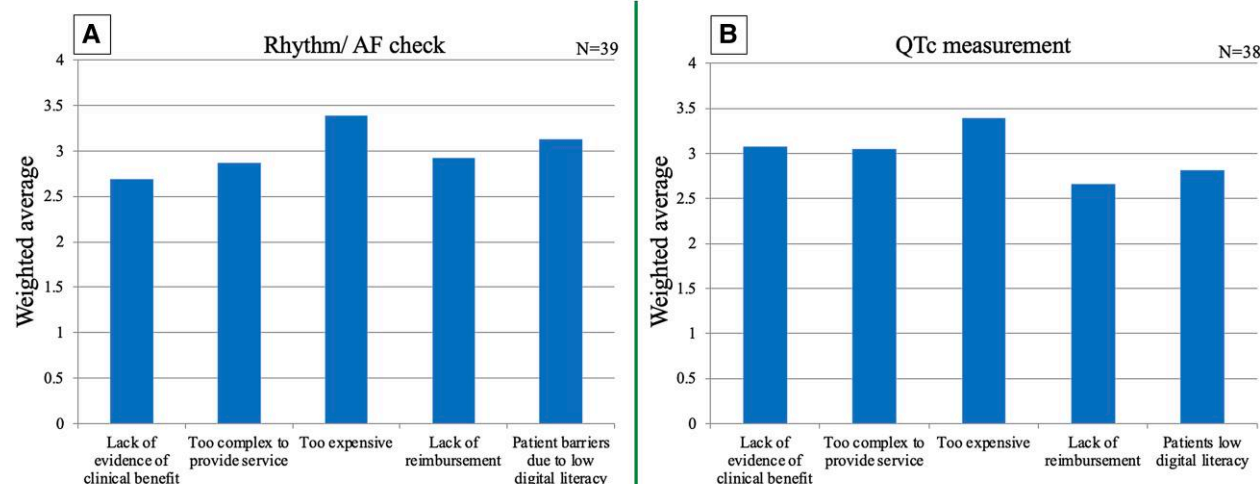
This is the first survey, to our knowledge, to explore practice among physicians regarding the use of mobile and wearable digital devices in the setting of cardio-oncology. Digital devices are now proposed to consumers not only in the field of wellness but also for various

purposes in the care of patients with CVDs or at risk of developing CVDs,<sup>17–20</sup> but relatively limited uptake occurred in the field of cardio-oncology.<sup>21,22</sup>

The majority of respondents highlighted that mobile/wearable devices have an important role in different settings of cardio-oncology, including monitoring of patients' parameters and arrhythmia detection. Mobile/wearable devices are considered useful for AF screening and AF burden monitoring in both symptomatic and asymptomatic patients. On the other hand, the role of these devices in monitoring physical activity and the QTc interval appeared more reserved and nuanced. A significant proportion of respondents did not advise active cancer patients to use any mobile/wearable devices and do not look after active cancer patients using mobile/wearable devices. The most important perceived barriers to device implementation for AF detection were high costs and low digital literacy of patients, while the high cost was reported as an important barrier for QTc monitoring.

Mobile/wearable devices offer the unique opportunity to monitor in real-time multiple objective and subjective patient parameters, including heart rate and rhythm, blood pressure, physical activity, sleep quality, oxygen saturation, symptoms, and mood.<sup>23,24</sup> This allows for improved patient phenotyping, outcome prediction, and cancer care delivery, including the pre-treatment, in-treatment, and survivorship time.<sup>25</sup> In seven out of eight clinical scenarios explored in the present survey, the greatest number of respondents reported that mobile/wearable digital devices have an important role in all patients with active cancer. These scenarios included measuring heart rate, blood pressure, body temperature, physical activity, sleep, AF detection, and oxygen saturation measurement. Conversely, the greatest number of respondents reported that mobile/wearable digital devices play a role only in selected patients for QTc interval measurement. Potential explanations for this finding might be that not all cancer patients are at risk of QTc interval prolongation, only some are prescribed with potentially QTc prolonging drugs, as well as that the QTc interval is not straightforward to measure and interpret.<sup>26</sup> In fact, most respondents identified two settings where cancer patients may benefit the most from mobile/wearable digital devices (e.g. patients who cannot attend the clinic and increased frequency of QTc measurement in patients at higher





**Figure 5** Limitations for the implementation of mobile/wearable digital devices in patients with active cancer for cardiac rhythm identification and atrial fibrillation detection (A) or QTc interval measurement (B).

risk of QTc interval prolongation), while their routine use in all patients was considered less often. On the other hand, few respondents believed that mobile/wearable digital devices have no role in cancer patient care. This finding underscores that mobile/digital devices will potentially have a pivotal role in the assessment and management of patients with cancer in the near future, also with the potential of extending their role to patient education, shared decision-making, patient-provider communication, and provision of psychological support.<sup>27</sup> Of note, responses of cardio-oncologists did not substantially differ when compared with those from other specialists.

Our results reinforce current evidence that physicians are prone to use mobile/wearable digital devices for AF detection and monitoring in both symptomatic and asymptomatic cancer patients, also taking into account the predisposition of cancer patients to share data on their clinical status with their providers.<sup>28</sup> As known, there is a bidirectional link between AF and cancer, since AF can be a marker of occult cancer, and patients with cancer are at significantly higher risk of developing incident AF and AF recurrences, at different stages of their disease.<sup>29</sup> Atrial fibrillation occurrence in cancer patients has been associated with a higher risk of systemic thromboembolism, stroke, HF, major bleeding, all-cause mortality, and oral anticoagulants under-prescription.<sup>30–33</sup> Therefore, mobile/wearable digital devices should be considered useful tools for early AF detection and early delivery of care.<sup>23,34,35</sup> Current guidelines<sup>1,36</sup> recommend to follow the 'ABC pathway' (Atrial fibrillation Better Care), which streamlines a holistic approach to patient care (A: anticoagulation to avoid stroke/systemic embolism; B: better symptom control with rate- and/or rhythm-control drugs and interventions; and C: comorbidities and cardiovascular risk factors management, including lifestyle changes).<sup>1,36,37</sup> Patient management according to the ABC pathway was found associated with clinical benefits and better outcomes, also in the population with AF and cancer.<sup>9</sup>

Our survey shows that a considerable proportion of physicians do not currently advise mobile/wearable digital devices and, when looking after active cancer patients in clinical practice, the decision to use the devices was taken by the patient in more than half of cases. As expected, patients aged  $\leq 75$  years were the best candidates for adopting this technology, in consideration of the less problematic

issue of digital literacy.<sup>15,38,39</sup> The results of our survey illustrate that mobile/wearable digital devices have the potential to promote patient empowerment and establish better ways for interaction between care providers and patients with improved monitoring of healthcare conditions.<sup>40–42</sup> Unfortunately, several issues need to be addressed in order to overcome implementation limitations and expand the use of digital devices to a broad population, including complex clinical scenarios. From a physician's perspective, lack of reimbursement,<sup>18,43</sup> lack of direct evidence of clinical benefit, and high complexity to provide service represent important barriers.<sup>22</sup> However, other factors such as gender, age, race/ethnicity, level of education, and income levels need to be considered for ensuring equitable access to digital technologies.<sup>14,44</sup>

## Limitations

In our survey, the majority of respondents were cardio-oncologists, who, given the specialized nature of the topic, may have been more inclined to respond. This group represents a highly specialized subset of physicians, as cardio-oncology is a relatively new and focused discipline. However, there was also substantial representation from other medical and non-medical specialties (see [Supplementary material online, Figure S3](#)). The heterogeneity of respondents' areas of practice may have influenced the results, as different subspecialties may approach patient management in varying ways. Although the survey was not designed to capture these differences, this diversity reflects the multidisciplinary nature of cardio-oncology, involving a broad spectrum of healthcare professionals. Moreover, our sub-analysis showed that responses of cardio-oncologists did not substantially differ when compared with those from other specialists. Selection bias and potential inaccuracy of self-reported data are intrinsic limitations of any survey. Similarly, healthcare providers who replied might be more interested in this topic and thus more prone to recommend mobile/wearable devices use in their patients. For the same reason, they may represent a more expert subset of healthcare providers. Additionally, some countries may be underrepresented due to a lower response rate or less familiarity with digital health devices. However, our survey includes substantial representation from Europe, North America, and South America.

In the future, the results of this survey may be of value to promote further robust prospective studies laying the foundation for a widespread use of mobile/digital devices in the setting of cardio-oncology.

## Conclusions

Mobile/wearable digital devices are considered by physicians to play an important role in different settings of cardio-oncology, including monitoring of active cancer patients' parameters and arrhythmia detection. Their role in monitoring physical activity and QTc interval remains to be determined. The most important perceived barrier to devices implementation is their high cost.

## Lead author biography



Professor Giuseppe Boriani, MD, PhD, FEHRA, FESC, FHFA, is a professor of cardiology at the University of Modena and Reggio Emilia and Chief of Cardiology at the University Hospital in Modena, Italy. He has served in several positions in European Heart Rhythm Association (EHRA), and he is currently the chair of the EHRA mHealth and Health Economics and PROM Committee. He is a member of the Council of Cardio-Oncology of the European Society of Cardiology.

## Supplementary material

[Supplementary material](#) is available at *European Heart Journal – Digital Health*.

## Acknowledgements

The members of Cardio-Oncology Council of the European Society of Cardiology acknowledge the important contribution of EHRA in the planning of this Survey.

## Funding

A.R.L. is supported by the Foundation Leducq Network of Excellence in Cardio-Oncology and the Royal Brompton Cardio-Oncology Centre of Excellence is supported by The Big Heart Foundation. P.A. is supported by the European Union—Next Generation EU—NRRP M6C2—Investment 2.1, Enhancement and strengthening of biomedical research in the NHS (PNRR-MAD-2022-12376632, CUP C63C22001360006).

**Conflict of interest:** A.R.L. has received speaker, advisory board, or consultancy fees and/or research grants from Pfizer, Novartis, Servier, AstraZeneca, Bristol Myers Squibb, GSK, Amgen, Takeda, Roche, Janssens-Cilag Ltd, Astellas Pharma, Clinigen Group, Eli Lilly, Eisai Ltd, Ferring Pharmaceuticals, Boehringer Ingelheim, Akcea Therapeutics, Myocardial Solutions, iOWNA Health, and Heartfelt Technologies Ltd. G.B. reported small speaker fees from Bayer, Boehringer Ingelheim, Boston, Daiichi Sankyo, Microport, Janssen, and Sanofi outside of the submitted work. J.L.M. reports fees and honoraria for lectures, education, and scientific advice from Biotronik, Microport & Zoll. P.A. received speaker and/or advisory board from AstraZeneca, Boehringer Ingelheim, Bayer, Daiichi Sankyo, Janssen, MSD, and Gossamer Bio. The other authors did not report conflicts of interest to disclose.

## Data availability

The data underlying this article are available in the article as well as in the online [Supplementary material](#).

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