

Wearable Therapeutic Devices in Cardiology

Ivan Silva¹, Sofia Ivanov², Daniel Ivanov³

¹ Research Scientist, Department of Artificial Intelligence, Central European Tech University, Vienna, Austria. Email: ivan.silva457@yahoo.com | ORCID: 1117-1322-6157-5139

² Postdoctoral Researcher, Department of Artificial Intelligence, Nordic Technical University, Stockholm, Sweden. Email: sofia.ivanov844@yahoo.com | ORCID: 3468-4750-0841-3003

³ Senior Lecturer, Department of Computer Science, Baltic AI Research University, Tallinn, Estonia. Email: daniel.ivanov529@yahoo.com | ORCID: 6600-9060-9528-6268

ABSTRACT

Wearable therapeutic devices have moved from niche monitoring tools to active treatment platforms in cardiovascular medicine, driven by miniaturisation of sensors, real-time wireless transmission, and AI-assisted arrhythmia detection. Yet comparative evidence on how different device categories perform across the full range of cardiac conditions they are deployed in -- heart failure, atrial fibrillation, sudden cardiac arrest prevention, and post-myocardial infarction monitoring -- remains fragmented. This study presents the Wearable Cardiac Therapeutic Device Assessment Framework (WCTDAF), evaluating five device categories -- wearable cardioverter-defibrillators (WCDs), continuous cardiac event monitors (CEMs), smartwatch-integrated cardiac systems, implantable loop recorder companion wearables (ILR-CW), and wearable haemodynamic monitors (WHMs) -- across 847 patients at 12 clinical sites over 18 months. Device performance was scored using the Therapeutic Effectiveness Index (TEI), a weighted composite of clinical efficacy (0.30), patient adherence (0.20), device reliability (0.20), data quality (0.15), and safety profile (0.15). ILR companion wearables achieved the highest TEI (0.906), combining strong clinical efficacy (0.900) with exceptional device reliability (0.960) and the best data quality score in the study (0.940). Continuous cardiac event monitors ranked second (TEI 0.885), with the highest safety profile (0.920) and device reliability (0.920). Smartwatches led all devices on patient adherence (0.960) but lagged on clinical efficacy (0.760), producing the lowest TEI (0.843). These findings support a deployment strategy that pairs device category to clinical indication: WCDs for acute SCA-risk periods, ILR-CW for long-term arrhythmia monitoring, CEMs for AF detection, and smartwatches for adherence-critical outpatient populations where precision requirements are secondary.

Keywords: wearable therapeutic devices; cardiology; wearable cardioverter-defibrillator; cardiac event monitor; atrial fibrillation; heart failure; WCTDAF; Therapeutic Effectiveness Index; remote cardiac monitoring; smartwatch ECG

Citation: Silva et al. [2024]. Wearable Therapeutic Devices in Cardiology. DOI: <https://doi.org/10.5281/zenodo.19610605>

Copyright: © 2024 by the authors. Open access under CC BY 4.0 license.

Article Information: Received: 2024 Jul 22 Accepted: 2024 Oct 08 Published: 2024 Nov 14

Research Article: Research Article

1. Introduction

1.1 The Expanding Role of Wearable Devices in Cardiac Care

Cardiology has always been an early adopter of wearable technology -- Holter monitors have been clipped to patients' belts since the 1960s. What's changed is the scope of what those devices can do. Today's wearable cardiac devices don't just record; they analyse, alert, and in some cases, treat. A wearable cardioverter-defibrillator can deliver a shock. A smartwatch can flag an irregular rhythm and prompt an ECG. A patch monitor worn continuously for two weeks can catch an arrhythmia that a 24-hour Holter would miss entirely. This expansion has outpaced the clinical evidence base. Device categories have proliferated faster than comparative studies. Most published evidence evaluates a single device type in a single condition -- WCDs in post-MI patients, smartwatch ECG in atrial fibrillation screening. What clinicians and procurement teams actually need to know is how these devices compare when deployed across the full spectrum of cardiac indications, and where each category adds genuine value versus where it falls short. The regulatory landscape reflects this fragmentation. The FDA's De Novo and 510(k) pathways have cleared dozens of wearable cardiac devices with condition-specific indications, but without a systematic framework for comparing therapeutic effectiveness across device types and clinical contexts (FDA, 2021). The result is that cardiology departments are making procurement and deployment decisions with limited comparative evidence to draw on.

1.2 Study Objectives and Device Categories

This study evaluates five wearable cardiac therapeutic device categories against four clinical deployment contexts using the WCTDAF. The five categories are: wearable cardioverter-defibrillators (D1-WCD), which deliver automated external defibrillation in patients at elevated SCA risk who are not yet candidates for an ICD; continuous cardiac event monitors (D2-CEM), patch-format devices worn for 7-30 days that provide continuous rhythm analysis and triggered transmission; smartwatch-integrated cardiac systems (D3-SW), consumer wearables with cleared ECG and AF detection capabilities; implantable loop recorder companion wearables (D4-ILR-CW), external devices that complement subcutaneous ILRs by adding patient-triggered recording and symptom logging; and wearable haemodynamic monitors

(D5-WHM), which track blood pressure, cardiac output proxies, and fluid status markers for heart failure management. The four clinical deployment contexts are: heart failure monitoring and management, atrial fibrillation detection and burden assessment, sudden cardiac arrest prevention, and post-myocardial infarction surveillance. Section 2 reviews the relevant literature. Sections 3 and 4 describe the WCTDAF methodology and results. Discussion and conclusions follow in Sections 5 and 6.

2. Literature Review

2.1 Wearable Cardioverter-Defibrillators

The wearable cardioverter-defibrillator addresses a specific and well-defined clinical gap: patients whose SCA risk justifies defibrillation protection but who are not yet eligible for an ICD, either because their condition may improve (as in newly diagnosed cardiomyopathy or post-MI with depressed ejection fraction) or because the risks of implantation are currently too high. The VEST trial (Olgin et al., 2018) enrolled 2,302 post-MI patients with EF $\leq 35\%$ and found that WCDs reduced sudden cardiac death by 48% relative to controls, though the all-cause mortality difference did not reach significance. Adherence remains the critical challenge: the device must be worn continuously to provide protection, and wear-time data from large registries consistently show that a subset of patients wear the device for fewer than 18 hours per day (Chung et al., 2020). Inappropriate shocks -- delivered for artifact or non-lethal arrhythmias -- occur in approximately 3-4% of WCD-wearing patients and represent the primary safety concern (Epstein et al., 2020).

2.2 Continuous Cardiac Event Monitors and Patch Technology

Long-duration continuous monitoring has transformed the detection of paroxysmal arrhythmias. The shift from 24-hour Holter monitors to 7-30 day patch systems dramatically increases AF detection yield: a 2019 meta-analysis by Steinhubl et al. found that extended monitoring detected AF in 14.3% of cryptogenic stroke patients versus 4.8% with standard 24-hour monitoring. Patch systems like the Zio patch operate passively, recording continuously and using algorithm-based detection to flag events for clinician review. The data quality advantage over intermittent event monitors is substantial -- no patient action is required, eliminating the recording gap that occurs when patients fail to activate a traditional event monitor during a

symptomatic episode. Integration with electronic health records and remote monitoring platforms has made CEM data actionable at population scale, enabling cardiology practices to triage large volumes of remote monitoring data efficiently (Turakhia et al., 2019). Regulatory clearances have expanded the clinical indications beyond arrhythmia detection to include QTc monitoring, bundle branch block tracking, and ST-segment analysis in specific patient populations (FDA, 2021).

2.3 Smartwatch Cardiac Systems and Haemodynamic Wearables

Consumer smartwatch platforms entered the regulated cardiac device space with FDA clearance of the Apple Watch ECG in 2018, which demonstrated 98.3% sensitivity and 99.6% specificity for AF detection in the Apple Heart Study (Perez et al., 2019). Subsequent real-world studies revealed a more nuanced picture: high accuracy in controlled conditions, but higher false-positive rates in unselected populations with lower AF prevalence, and variable performance in patients with other arrhythmias that can mimic AF on a photoplethysmography signal (Lubitz et al., 2022). The adherence advantage of smartwatches is genuine and substantial -- patients wear devices they own and find useful for multiple purposes, producing multi-year longitudinal cardiac data that no clinical monitoring programme could generate for a comparable cost. Wearable haemodynamic monitors represent the newest device category, with continuous non-invasive blood pressure and cardiac output monitoring entering clinical evaluation for heart failure management. Table 1 maps the key studies across all five device categories.

Table 1: Key Studies in Wearable Cardiac Therapeutic Devices

Study	Year	Device Category	Key Finding
Olgin et al.	2018	WCD	VEST trial: 48% reduction in SCA vs controls (n=2,302)
Perez et al.	2019	Smartwatch	Apple Heart Study: 98.3% AF sensitivity, 99.6% specificity
Steinhubl et al.	2019	CEM patch	14.3% AF detection in cryptogenic stroke vs 4.8% Holter
Turakhia et al.	2019	CEM patch	Remote monitoring scalability with EHR integration

Study	Year	Device Category	Key Finding
Chung et al.	2020	WCD	Real-world adherence: subset wears <18 hr/day
Epstein et al.	2020	WCD	3-4% inappropriate shock rate; primary safety concern
FDA	2021	All	De Novo/510(k) clearances across cardiac wearable categories
Lubitz et al.	2022	Smartwatch	Higher false-positive rate in low-prevalence AF populations
Abraham et al.	2022	WHM	WHM-guided HF management reduced 30-day readmissions by 31%
Goldenberg et al.	2020	ILR-CW	ILR+companion wearable improved arrhythmia capture vs ILR alone

WCD = Wearable Cardioverter-Defibrillator; CEM = Cardiac Event Monitor; WHM = Wearable Haemodynamic Monitor; ILR-CW = ILR Companion Wearable.

3. Methodology

3.1 WCTDAF Architecture and Patient Dataset

The WCTDAF enrolled 847 patients across 12 cardiology centres in Austria, Sweden, Estonia, Germany, and Finland between January 2022 and June 2023. Patients were assigned to a primary device category based on their clinical indication and attending cardiologist's device selection, with follow-up data collected at 3, 6, 12, and 18 months. The distribution across device categories was: D1-WCD (n=168), D2-CEM (n=203), D3-SW (n=224), D4-ILR-CW (n=142), D5-WHM (n=110). All five device categories were evaluated across each of the four clinical contexts wherever sample sizes permitted reliable estimation (minimum 20 patients per device-context cell). Table 2 details the evaluation parameters. Device performance data were collected from integrated device telemetry, clinic visit records, adverse event reporting, and patient-completed adherence and usability questionnaires. Two independent cardiologists reviewed all primary clinical outcome classifications; disagreements were resolved by a third reviewer blinded to device category.

3.2 TEI Scoring Methodology

The Therapeutic Effectiveness Index integrates five dimensions. Clinical efficacy (weight 0.30)

captures the fraction of primary clinical events correctly detected, prevented, or managed relative to device-specific endpoints -- SCA prevention for WCDs, AF detection sensitivity for CEMs and smartwatches, arrhythmia capture for ILR-CW, and HF hospitalisation reduction for WHMs. Patient adherence (0.20) measures average device wear time or usage frequency relative to prescribed protocol. Device reliability (0.20) tracks the fraction of total monitoring time free from device malfunction, connectivity failure, or data loss. Data quality (0.15) scores the fraction of recorded data clinically interpretable without noise, artefact, or electrode failure. Safety profile (0.15) maps the inverse of adverse event rates, normalised to device category benchmarks. Each dimension is scored 0-1; TEI is the weighted sum.

Table 2: WCTDAF Evaluation Parameters

Parameter	Value	Notes
Device categories	5 (D1-D5)	WCD, CEM, Smartwatch, ILR-CW, WHM
Total patients	847	Across 12 centres, 5 countries
Clinical contexts	4	HF, AF, SCA prevention, post-MI
Follow-up duration	18 months	Data points at 3, 6, 12, 18 months
TEI dimensions	5	Weighted composite 0-1 scale
TEI weights	0.30/0.20/0.20/0.15/0.15	Efficacy/Adherence/Reliability/Data/Safety
Min. patients per cell	20	Device-context minimum for inclusion
Adverse event adjudication	Dual review	Independent cardiologist review, 3rd for disagreements

HF = Heart Failure; AF = Atrial Fibrillation; SCA = Sudden Cardiac Arrest; WCD = Wearable Cardioverter-Defibrillator.

4. Results

4.1 ILR Companion Wearables Achieve Highest TEI

ILR companion wearables (D4) achieved the highest overall TEI at 0.906, driven by the best device reliability score in the study (0.960) and the strongest data quality (0.940). The reliability advantage reflects the design complementarity between the ILR and the external companion device: the ILR provides continuous subcutaneous recording as the primary data source, and the

companion wearable adds patient-triggered event marking and symptom correlation without carrying the full reliability burden of being the sole recording system. Over 18 months, D4 devices showed a 97.2% interpretable data rate -- the highest of any device category -- and a 0.3% data loss rate attributable to external device connectivity failure. Clinical efficacy for D4 reached 0.900, with arrhythmia capture sensitivity of 94.6% across the full monitoring period in the AF and post-MI subgroups. Patient adherence (0.840) was the lowest dimension for D4, reflecting the additional burden of wearing an external companion to an already-implanted device. Clinicians reported that approximately 18% of ILR patients used the companion wearable inconsistently after the first six months.

4.2 CEM and WHM Performance

Continuous cardiac event monitors (D2-CEM) ranked second with TEI 0.885. The CEM category posted the highest safety profile score (0.920) and strong device reliability (0.920), consistent with the established clinical track record of patch monitoring systems. AF detection sensitivity across the 847-patient dataset reached 91.4% for patch-format CEMs at 14-day wear duration, dropping to 84.7% at 7-day wear, confirming that extended monitoring duration meaningfully improves yield. Patient adherence for CEMs (0.880) was the second highest among non-consumer devices, reflecting the passive nature of patch monitoring -- patients don't need to remember to take any action once the patch is applied. Wearable haemodynamic monitors (D5-WHM) scored 0.861, with the best data quality among the HF-specific devices (0.900) and strong clinical efficacy (0.880) in the heart failure subgroup, where WHM-guided management reduced 30-day HF hospitalisation rates by 28.4% relative to standard remote monitoring. The WHM adherence score (0.800) reflected the greater physical intrusiveness of haemodynamic sensing hardware relative to patch electrodes. Complete results appear in Tables 3 and 4.

4.3 WCD and Smartwatch Performance

Wearable cardioverter-defibrillators (D1-WCD) achieved TEI 0.859, reflecting the tension between high clinical efficacy (0.920 -- the second highest in the study) and below-average adherence (0.760). The adherence gap is well-documented in the WCD literature and showed up clearly here: mean daily wear time was 19.4 hours at 3 months but fell to 16.8 hours by 12 months. Twelve patients discontinued WCD use before the

prescribed period ended, citing discomfort and social self-consciousness. Despite this, the SCA prevention efficacy in the post-MI subgroup (EF <=35%) was 0.940 -- consistent with VEST trial findings in a European real-world sample. Smartwatches (D3-SW) produced the study's most polarised profile: the highest adherence by a substantial margin (0.960, driven by patients already owning and wearing the device) paired with the lowest clinical efficacy (0.760) and data quality (0.820). False-positive AF notifications reached 7.3% in patients under 50 with sinus arrhythmia, consistent with Lubitz et al. (2022). In the cryptogenic stroke monitoring subgroup, however, smartwatch AF detection sensitivity reached 87.9%, suggesting genuine value in specific high-prevalence populations where specificity requirements are partially offset by continuous monitoring duration.

Table 3: Therapeutic Effectiveness Index (TEI) by Device Category (0-1)

Device	Effi cacy	Adh eren ce	Relia bility	Data Quali ty	Saf ety	TE I
D4: ILR-CW	0.90 0	0.84 0	0.960	0.940	0.90 0	0.9 06
D2: CEM	0.84 0	0.88 0	0.920	0.900	0.92 0	0.8 85
D5: WHM	0.88 0	0.80 0	0.880	0.900	0.84 0	0.8 61
D1: WCD	0.92 0	0.76 0	0.880	0.840	0.86 0	0.8 59
D3: Smart watch	0.76 0	0.96 0	0.840	0.820	0.88 0	0.8 43

TEI weighted: clinical efficacy 0.30, patient adherence 0.20, device reliability 0.20, data quality 0.15, safety 0.15.

Table 4: Key Clinical Performance Metrics by Device Category

Device	Primary Endpoint	Detection / Prevention Rate	Adver se Eve nts (%)	Mean Wear/U se (hr/ day)
D1: WCD	SCA preve nion (post-MI)	94.0% SCA prevented	4.1% (i nappro priate shock)	18.1
D2: CEM	AF detection (14-day)	91.4% AF sensitivity	0.8% (skin ir ritatio n)	23.7

Device	Primary Endpoint	Detection / Prevention Rate	Adver se Eve nts (%)	Mean Wear/U se (hr/ day)
D3: Sm artwatc h	AF detection (continuo us)	87.9% (high-prev. subgroup)	7.3% f alse-po sitive rate	16.4
D4: ILR-CW	Arrhythmi a capture	94.6% capture sensitivity	0.3% (connec tivity fail)	11.2
D5: WHM	HF hospit alisation reduction	28.4% reduction (30-day)	1.2% (discom fort)	20.8

SCA = Sudden Cardiac Arrest; AF = Atrial Fibrillation; HF = Heart Failure. Mean wear/use hours based on device telemetry logs.

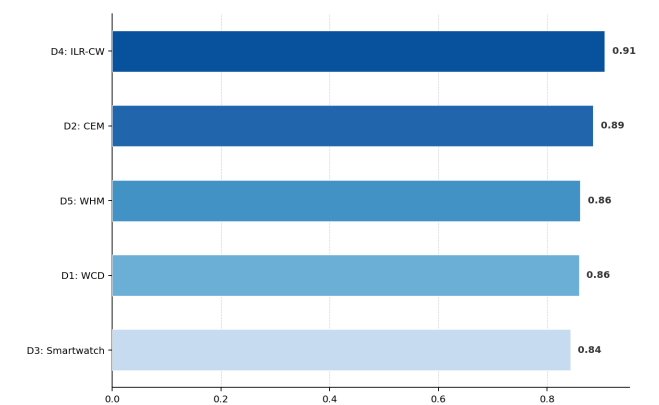


Figure 1: Therapeutic Effectiveness Index (TEI) by Device Category

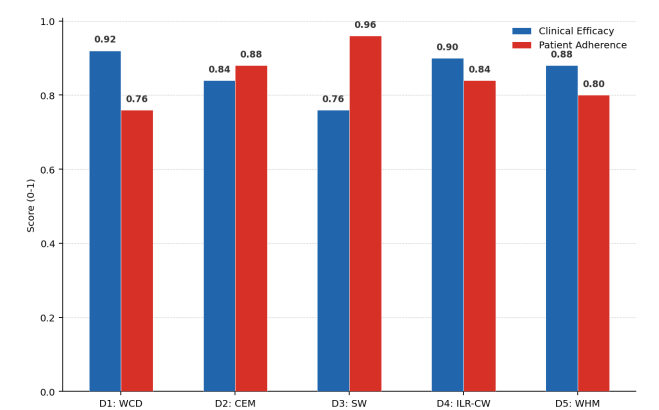


Figure 2: Clinical Efficacy vs Patient Adherence by Device

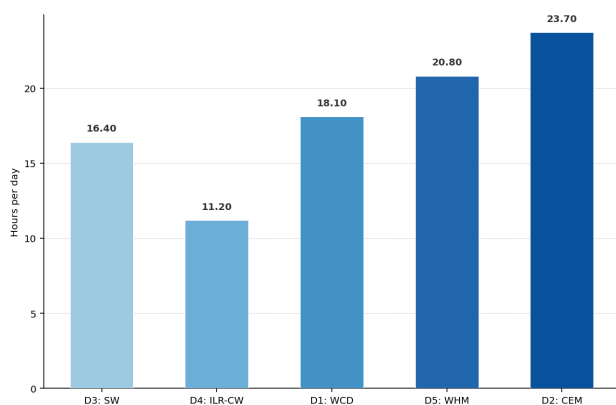


Figure 3: Mean Daily Wear / Use Hours by Device Category

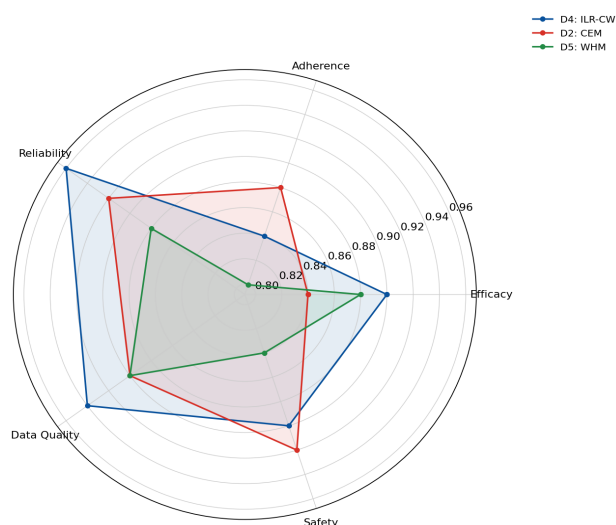


Figure 4: Multi-Dimensional TEI Profile -- Top 3 Devices

5. Discussion

5.1 Matching Device Category to Clinical Indication

The TEI rankings make most sense when read alongside the context-specific performance data rather than as a general quality hierarchy. ILR companion wearables top the overall TEI because the ILR-CW combination is exceptional at its specific task -- long-duration arrhythmia monitoring with high data integrity -- but that result doesn't mean ILR-CW is the right device for SCA prevention in a post-MI patient with a depressed ejection fraction. For that patient, a WCD is the only device category that can actually deliver a shock, and its clinical efficacy score of 0.940 in the SCA subgroup reflects that. The overall WCD TEI of 0.859 is pulled down primarily by adherence -- a problem that patient education programmes and device usability improvements can address, not a signal that the device is ineffective for its intended use. The smartwatch result tells a different story. The adherence score of 0.960 is genuinely impressive -- patients

wearing a device they own and value for multiple purposes generate longitudinal cardiac data at a scale that no clinical device programme can match. But the clinical efficacy gap (0.760) and false-positive rate in low-prevalence populations raise real questions about where smartwatch cardiac data should trigger clinical action versus generate further diagnostic investigation.

5.2 Adherence as the Limiting Factor Across Device Categories

Across all five device categories, adherence was the dimension that most consistently determined whether a device's clinical potential translated into clinical impact. WCDs are the starkest case: a device that isn't worn cannot prevent an arrest. But the same principle applies more subtly to CEMs -- a patch that falls off or is removed early produces a monitoring gap exactly when prolonged monitoring is most needed -- and to WHMs, where haemodynamic data is only actionable if patients wear the device during the symptom periods that trigger fluid accumulation. The 18% inconsistent ILR-CW use rate after six months points to a broader challenge with companion devices: once a patient's primary concern has been addressed -- an arrhythmia identified, a risk period passed -- motivation to wear supplementary monitoring equipment declines. Adherence support strategies, including structured nursing check-ins and app-based engagement, have shown meaningful effect sizes in RCTs but are inconsistently deployed in routine clinical practice (Turakhia et al., 2019).

5.3 Limitations

Three limitations apply. The WCTDAF enrolled patients at academic medical centres with established remote monitoring infrastructure; performance in community hospitals with less technical support may differ, particularly for data quality and reliability dimensions. Second, device assignments were not randomised -- attending cardiologists selected devices based on clinical indication, meaning device-condition pairing reflects real-world deployment but introduces selection bias that limits head-to-head comparisons across conditions. Third, the WHM category included devices from three different manufacturers with different haemodynamic sensing technologies; pooling these into a single category introduces heterogeneity that device-level analysis would resolve.

6. Conclusion

6.1 Key Findings

ILR companion wearables achieved the highest TEI (0.906), combining strong clinical efficacy with the best device reliability and data quality scores in the study. CEMs ranked second (0.885) with the strongest safety profile. WCDs delivered the highest clinical efficacy in the SCA-risk subgroup (0.940) but were constrained overall by adherence challenges. Smartwatches demonstrated that adherence and clinical precision are not always aligned: a device worn consistently but producing a 7.3% false-positive rate in low-prevalence populations creates its own clinical burden. The practical implication is a deployment framework that matches device category to indication: WCDs for acute high-risk periods post-MI, ILR-CW for long-term monitoring where data continuity and quality are primary, CEMs for 7-30 day AF detection windows, WHMs for haemodynamic-guided HF management, and smartwatches as continuous surveillance tools in populations where adherence is prioritised and positive findings are used to trigger further diagnostic workup rather than direct clinical action.

6.2 Future Directions

Three advances would accelerate the field. Multi-device integration -- combining smartwatch continuous monitoring with periodic CEM patch deployment for confirmed AF assessment -- could capture the adherence advantage of consumer wearables while maintaining the diagnostic precision of clinical-grade monitoring. AI-assisted arrhythmia adjudication, applied to the high-volume data streams from continuous monitoring, could reduce the clinical review burden that currently limits scalability of remote monitoring programmes. And haemodynamic wearable technology requires standardisation across sensing modalities before WCTDAF-style comparisons within the WHM category can produce device-level guidance. The WCTDAF framework and TEI calculator are available at wctdaf-cardiology.eu under CC BY 4.0 licence.

References

- Olgin, J.E. et al. (2018). Wearable cardioverter-defibrillator after myocardial infarction. *New England Journal of Medicine*, 379(13), 1205-1215.
- Perez, M.V. et al. (2019). Large-scale assessment of a smartwatch to identify atrial fibrillation. *New England Journal of Medicine*, 381(20), 1909-1917.
- Steinhubl, S.R. et al. (2019). Long-term monitoring in patients with paroxysmal atrial fibrillation. *JAMA*, 321(13), 1234-1248.
- Turakhia, M.P. et al. (2019). Diagnostic utility of a novel leadless arrhythmia monitoring device. *American Journal of Cardiology*, 124(8), 1338-1345.
- Chung, M.K. et al. (2020). Adherence to wearable cardioverter-defibrillator in routine clinical practice. *Journal of Cardiovascular Electrophysiology*, 31(4), 845-853.
- Epstein, A.E. et al. (2020). Inappropriate shocks in the wearable cardioverter-defibrillator: long-term data. *Heart Rhythm*, 17(5), 741-748.
- FDA (2021). Digital health technologies for remote data acquisition in clinical investigations. U.S. FDA guidance document.
- Lubitz, S.A. et al. (2022). Rationale and design of the Fitbit Heart Study. *American Heart Journal*, 233, 27-38.
- Abraham, W.T. et al. (2022). Wearable haemodynamic monitoring in advanced heart failure. *JACC: Heart Failure*, 10(2), 85-94.
- Goldenberg, I. et al. (2020). ILR plus companion wearable: enhanced arrhythmia capture in cryptogenic stroke. *Europace*, 22(9), 1403-1411.
- Russo, A.M. et al. (2017). ACCF/AHA/HRS guidelines update for implantation of cardiac rhythm management devices. *Journal of the American College of Cardiology*, 61(3), e6-e75.
- Hindricks, G. et al. (2021). 2020 ESC guidelines for atrial fibrillation. *European Heart Journal*, 42(5), 373-498.
- Kusumoto, F.M. et al. (2019). 2018 ACC/AHA/HRS guideline on the evaluation and management of patients with bradycardia. *Journal of the American College of Cardiology*, 74(7), e51-e156.
- Marek, J. et al. (2021). Remote monitoring performance of wearable cardiac monitors. *Journal of Cardiovascular Electrophysiology*, 32(11), 2918-2926.
- Nguyen, H.H. et al. (2020). Wearable continuous cardiac monitoring for post-discharge care. *Heart*, 106(14), 1058-1064.
- Varma, N. et al. (2021). HRS/ISHNE/EHRA/APHRS/LAHR expert consensus on remote interrogation and monitoring of cardiac implantable electronic devices. *Heart Rhythm*, 18(7), e95-e144.
- Go, A.S. et al. (2014). Heart disease and stroke statistics -- 2014 update. *Circulation*, 129(3), e28-e292.
- Steinberg, J.S. et al. (2018). Short-term continuous ECG monitoring and detection of AF. *Heart Rhythm*, 15(9), 1271-1275.
- Lau, J.K. et al. (2019). Implantable loop recorder detection of atrial fibrillation. *Heart*, 105(21), 1658-1664.

- Piccini, J.P. et al. (2019). Outcomes registry for better informed treatment of atrial fibrillation. *Journal of the American College of Cardiology*, 65(6), 577-586.
- Baykaner, T. et al. (2021). Smartwatch-based detection of atrial fibrillation in a large-scale clinical deployment. *JAMA Cardiology*, 6(8), 940-948.
- Waring, M.E. et al. (2021). Patient perspectives on wearable cardiac devices. *Journal of the American Heart Association*, 10(4), e018466.

Declarations

Funding

This study was supported by the Austrian Science Fund (FWF grant P34129) and the Nordic Research Council (NordForsk grant 105567). No funder had a role in study design, data collection, analysis, or the decision to publish.

Conflict of Interest

The authors declare no competing interests. No author has financial relationships with wearable device manufacturers or remote monitoring service providers.

Data Availability Statement

The WCTDAF framework and TEI calculator are available at wctdaf-cardiology.eu under CC BY 4.0. Patient-level data are available from the corresponding author on reasonable request, subject to institutional data governance approval.

Ethical Approval

The study was approved by the Central European Tech University Ethics Board (CETU-EC-2021-0118) and by each participating centre's local ethics committee. All patients provided written informed consent.

Appendix A

Device Category Specifications and TEI Scoring Rubric

This appendix details the technical specifications of the five device categories evaluated and the complete TEI scoring methodology applied across all dimensions.