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Optimising IDTF Efficiency: Reducing False ECG Alarms with Automated Signal Quality Analysis

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Abstract

Independent Diagnostic Testing Facilities (IDTFs) face a significant burden from false alarms during remote cardiac monitoring.

Mobile cardiac telemetry (MCT) devices with onboard algorithms enable remote ECG monitoring capable of automated arrhythmia detection or real-time symptom recordings, which are transmitted to IDTFs for review by ECG technicians. To mitigate the risk of missing life-threatening arrhythmia events, traditional on-device algorithms are lenient to rhythm changes and are, therefore, susceptible to a high burden of false alarms. These false alarms require manual review by technicians, resulting in increased workload, reduced efficiency, and unreimbursed labour.

In this study, we evaluated the impact of integrating HeartKey Rhythm, an FDA-cleared ECG analysis software that uses signal quality indicators to identify and exclude low-quality ECG data, into the IDTF workflow.

A three-phase study, retrospective, prospective, and live clinical integration, was conducted to assess the efficacy of the software in reducing false alarm events.

The first two phases were designed to establish clinically acceptable thresholds for discarding data based on HeartKey Rhythm outputs. In these phases, HeartKey Rhythm achieved a 32.4% (>19,000 events) and 40.6% (>33,000 events) relative reduction in false alarms requiring manual review.

In the final phase, HeartKey Rhythm was integrated into a live IDTF during a 5-week pre-post analysis. Across >111,000 ECG events, HeartKey Rhythm achieved a 49.3% relative reduction in false alarms requiring manual review, resulting in estimated technician time savings of 27.6 hours per week.

These findings demonstrate that accurate signal quality classification can substantially reduce false alarm burden in IDTF workflows, improving operational efficiency and reducing technician workload.

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Introduction

Independent Diagnostic Testing Facilities (IDTFs) perform diagnostic tests independently of physicians' offices or hospitals. In an IDTF ambulatory ECG workflow, patients wear mobile monitors (e.g. Holter monitors or mobile cardiac telemetry devices) that continuously record cardiac activity over days or weeks. These devices can automatically detect potential arrhythmias through on-device algorithms or be manually activated by the patient to record symptomatic events. Once an event is detected, either automatically or manually, the ECG data are typically transmitted via wireless connection to a remote monitoring centre (the IDTF) in near real time.

At the IDTF, certified ECG technicians staff the centre 24/7 to review incoming data and alarms. They analyse the transmitted ECG strips to confirm if an arrhythmia has been correctly identified by the on-device solution or re-classify an incorrect classification.

To mitigate the risk of missing life-threatening arrhythmia events, the on-device algorithms are lenient to rhythm changes and are, therefore, susceptible to a high burden of alarms.

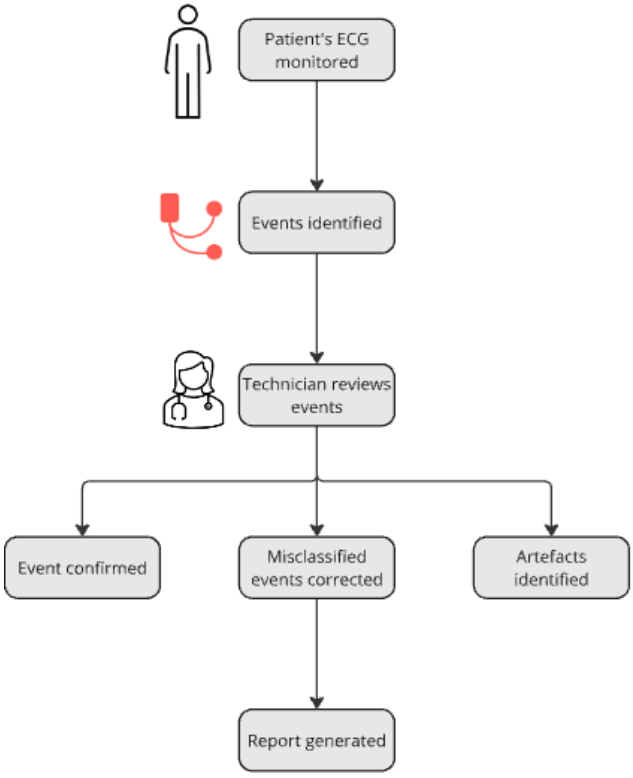

Figure 1: IDTF ambulatory ECG workflow

The False Alarm Problem

Poor ECG signal quality directly undermines the interpretability of ambulatory monitoring data. When an ECG tracing is corrupted by artefact, it becomes difficult for automated algorithms and human readers to correctly identify true cardiac events, which could lead to a false diagnosis. The image below provides an example of how artefact in the signal can impact the interpretability of the recording.

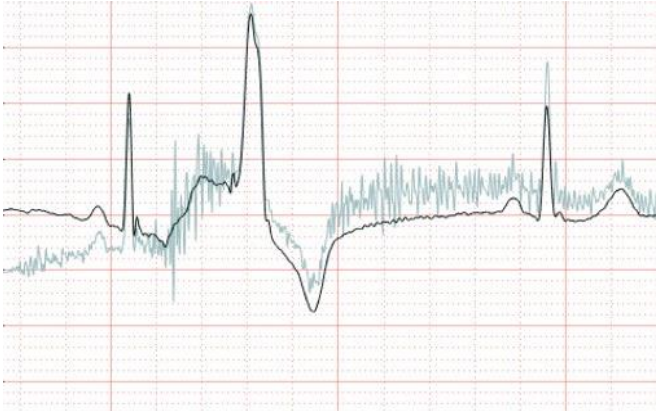

Figure 2: ECG signal before (grey) and after (black) filtering

Clinical Impact in an IDTF

Ambulatory ECG monitoring is susceptible to various artefacts and interferences that can trigger false alarms (alerts that mimic arrhythmias but are not true cardiac events) due to deflections in the signal that simulate arrhythmias on the ECG tracing. The image below shows a false ventricular tachycardia (VT) alarm triggered by artefact in leads I and II. Proof that this is a false positive alarm is provided by observing Lead III, which shows visible P-QRS-T waveforms indicating normal sinus rhythm [1].

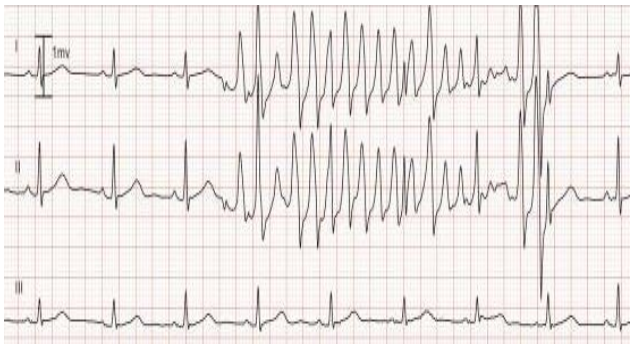

Figure 3: ECG signal displaying a false VT alarm due to artefact in leads I and II

The ECG strip with an incorrect label is presented to the technician during their standard working procedure. The technician must interpret the signal before deciding whether the strip has a true arrhythmia or if it is another false alarm incident. Two scenarios can occur:

1. The technician identifies the strip as a false alarm and discards the ECG strip. This is the best outcome to an inefficient situation, although this comes with a time burden spent interpreting an unactionable event.
2. The technician fails to identify the false alarm, and the results are transmitted to the physician for approval and sign-off.

Prevalence of False Alarms

Whether in-hospital or ambulatory cardiac monitoring, noise and false alerts increase the burden on the workforce, drain resources, and contribute to burnout. Previous research has highlighted the significant burden of false alarms from various monitoring methods, including implantable loop recorders, intensive care units, in-hospital telemetry, and ambulatory monitoring [2-5].

Like other clinical settings, the burden of false alarms on the IDTF is evident. A high prevalence of noise forces healthcare professionals to manually review and discard large volumes of ECG data, which is time-consuming for the technician. The burden is compounded by the fact that current reimbursement models often don't account for the time technicians spend reviewing and editing out noise. A recent American Heart Association scientific statement noted that most of the time and effort clinicians spend reviewing data from ambulatory devices is not reimbursed and may not improve patient outcomes [6].

The HeartKey Solution

B-Secur have developed a solution to address this challenge. Powered by an FDA-cleared advanced ECG algorithm suite (HeartKey Rhythm), IDTFs can implement signal quality indicators that accurately identify and discard ECG segments of low signal quality that are not sufficient for interpretation.

A three-phase study was performed at an IDTF to assess the impact of HeartKey Rhythm in reducing false alarm burden. The study evaluated the efficacy of integrating the solution into the typical IDTF workflow.

Study Aims

The primary aim of this study was to evaluate the impact of HeartKey Rhythm on the clinical workflow of an IDTF. By integrating automated signal quality indicators, we sought to reduce the time healthcare professionals spend reviewing unactionable ECG data, thereby enhancing workflow efficiency. The three phases were designed with the following aims:

Table 1: Aims and objectives of each study phase

Phase	Objective
I: Retrospective	Define clinically relevant thresholds for discarding unactionable ECG data before retrospectively quantifying the reduction in false alarm events [7].
II: Prospective	Optimising the previously defined thresholds before prospectively quantifying the reduction in false alarm events during a one-week integrative testing period.
III: In Production	Integrating the solution into a live IDTF workflow and quantifying the differences in false alarm events before and after integration.

Study Design

We conducted a three-phase study on patients who were referred to an IDTF (TZ Medical, Tualatin) for continuous cardiac monitoring, utilizing a three-channel cardiac monitor (Trident®). The design of each phase is described below:

Phase I: Retrospective

- 19,392 ECG arrhythmia events (35 seconds) from 291 patients were retrospectively analysed.
- The HeartKey Rhythm Signal Quality algorithm assessed each lead individually and classified two-second segments as ‘low’ or ‘high’ quality using the following criteria:

Table 2: HeartKey Rhythm Signal Quality algorithm classification criteria

Signal Quality Classification	Criteria
Low	QRS complexes cannot be detected reliably, and the signal is unsuitable for any analysis.
High	QRS complexes are clearly visible, and the signal enables reliable QRS detection.

- Overall event quality was based on the proportion of segments assigned 'low' quality and was validated against manual annotations at three graded 'low' quality proportional thresholds (>80%, >90%, >99% of event).
- An aggregate metric derived from the lead with the lowest percentage of ‘low’ quality data per event was used to represent the best-case scenario.
- The number of false alarms from the dataset was retrospectively quantified [7].

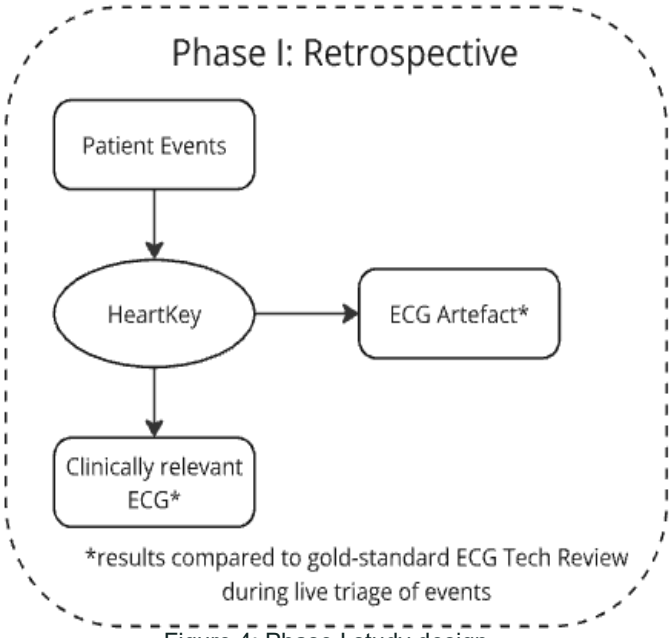

Figure 4: Phase I study design

Phase II: Prospective

- A prospective, two-arm analysis of 33,249 events over a one-week period was conducted. Events ranged from 60-180 seconds (mean: 72 seconds) and totalled 669 hours of ECG data.
- The thresholds identified in Phase I were optimised, resulting in a change of focus from the percentage of unactionable data to the duration of unactionable data.

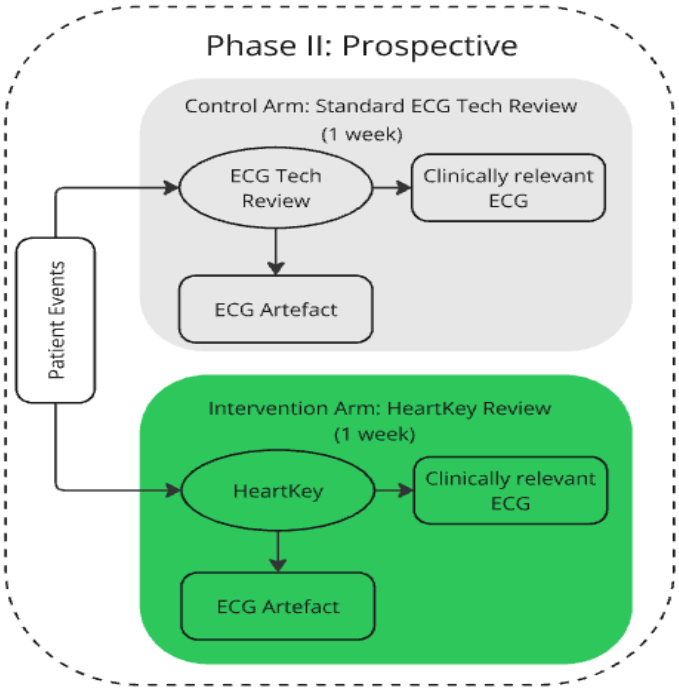

Figure 5: Phase II study design

Phase III: In Production

- A single-arm, pre-post design in an IDTF workflow was conducted over two consecutive 5-week periods, one before and one after the integration of HeartKey Rhythm.
- 111,503 events from 643 patients (55,813 pre-integration; 55,690 post-integration) were reviewed by technicians (N = 20) over 10 weeks.
- The algorithm screened events prior to technician review, excluding those with less than 8 seconds of combined high-quality data across three leads, based on a predefined clinical threshold determined from Phase II.
- The proportion of false alarm reviews (Artefact or Lead Off) was compared pre and post-HeartKey Rhythm integration in the live ITDF workflow.

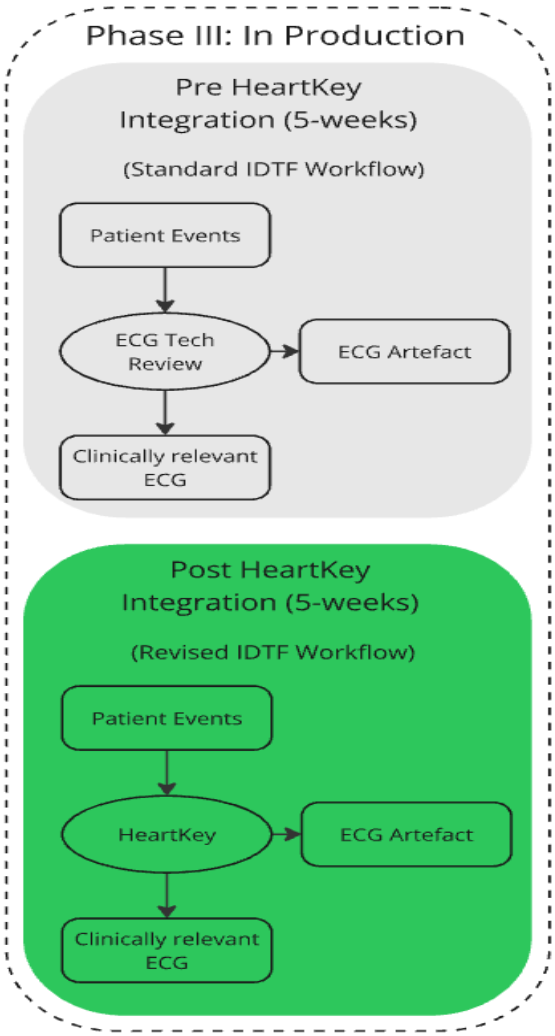

Figure 6: Phase III study design

Results

The three-phase analysis demonstrated excellent results in identifying and reducing the burden of false alarm events in an IDTF. The results across all phases are outlined below:

Phase I: Retrospective

- By applying a clinically acceptable threshold where >90% of an event (>31.5 seconds) had been classified by HeartKey Rhythm as low quality, HeartKey Rhythm demonstrated a relative reduction in the number of false alarms that required manual review by **32.4%**, with only a negligible **0.3%** chance of discarding clinically relevant data.
- Based on an estimation that an interpreter reviews 50 events daily, each taking two minutes, this threshold could allow for the review of **5 additional events per day** [7].

Phase II: Prospective

- Healthcare professionals determined that <8 seconds of combined high-quality data across the aggregate lead would be deemed unactionable, translating to a proportional threshold, as defined in Phase 1, ranging from 87.7% to 95.6%.
- By applying the optimised threshold of <8 seconds of high-quality data, manual ECG reviews decreased by **17.1%**, with artefact-related events dropping by a relative **40.6%**. Specificity remained high at **99.8%**, ensuring minimal risk of discarding valuable data
- For a healthcare professional reviewing 50 events per day at an average two-minute review time per event, this equates to a **daily time saving of >17 minutes**, enabling the review of an **additional 8.6 events per day**.

Phase III: In Production

- Upon integrating HeartKey Rhythm into the IDTF workflow, false alarms requiring manual review decreased from 8,414 (15.1%) pre-integration to 4,263 (7.7%) post-integration, a **49.3% relative reduction**.
- Artefact and Lead Off proportions decreased by **36.4%** and **72.7%**, respectively.
- At an average review time of two minutes per event, these reductions were **estimated to save 27.6 hours per week** post-integration, equating to **83 minutes saved per technician each week.**

Table 3: Results of the three-phase analysis

Phase	Events	Relative False Alarm Reductions (%)
I: Retrospective	19,392	32.4
II: Prospective	33,249	40.6
III: In Production	111,503	49.3

>111,000
Events

49.3%
Relative false alarm reductions

27.6 hours
Estimated time savings per week

Conclusion

The results of this study demonstrate that HeartKey Rhythm effectively reduces the burden of false alarm events in an IDTF. Across all three phases, large burdens of false alarm events were identified and discarded using highly accurate signal quality indicators. These findings have direct implications for clinical workflow, particularly in the following areas:

Reduced Technician Burden

By filtering out low-quality ECG data, HeartKey Rhythm reduced the need for manual review by 49.3% in a live IDTF workflow, freeing up an estimated 27.6 hours per week for technicians.

Improved Efficiency

With fewer false alarms requiring review, technicians could process more actionable events per shift, leading to faster diagnoses and improved patient management.

Cost Savings

Since 27.6 hours per week were saved, reducing manual workload translates to cost savings for IDTFs.

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