Wireless EKG

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I. CLINICAL CONTEXT & NARRATIVE

Continuous cardiac monitoring is essential in high-acuity human settings such as intensive care units (ICUs), emergency departments, perioperative suites, and telemetry floors, and in veterinary ICU and surgical recovery units. Clinicians rely on uninterrupted electrocardiogram (ECG) signals to detect arrhythmias, assess stability, and guide decisions. Yet wireless monitoring remains vulnerable to signal dropouts, lead detachment, and device interference, compromising safety and workflow. In veterinary hospitals, movement, chewing, scratching, and fur-covered skin further reduce adhesion, damage equipment, and disrupt transmission.

Unreliable ECG monitoring has serious clinical consequences: even brief interruptions can cause missed arrhythmias, delayed intervention, false alarms, and alarm fatigue (Cvach, 2012). Poor lead adhesion and motion artifact are leading causes of inaccurate or interrupted monitoring, limiting rapid response during cardiac events (Sendelbach & Funk, 2013). In veterinary care, patient-related interference also increases replacement costs, reduces device availability, and adds workflow burden.

Reliable, durable wireless ECG transmission is therefore a patient-safety priority. Improving signal robustness and reducing physical failure points could improve efficiency, reduce equipment damage, and support real-time detection of early abnormalities. Because cardiac deterioration can escalate within seconds in humans and animals, more dependable wireless ECG monitoring could improve outcomes and workflow across care settings (American Heart Association, 2020).

II. BIODESIGN NEED STATEMENT

Overall, we are looking for a way to improve the reliability, durability and continuity of wireless cardiac monitoring in human and veterinary patients across clinical care settings by reducing signal loss, interference and device damage during real-time EKG transmission.

III. EVIDENCE OF NEED

Reliable cardiac monitoring is essential in human and veterinary care, yet wireless ECG systems often fail to deliver continuous, high-quality data. Evidence shows signal loss, equipment damage, and workflow interruptions are common and harmful. Studies report 30–35% of wireless ECG disruptions stem from interference, poor electrode contact, or brief communication dropouts. These gaps matter: arrhythmias cause 450,000+ U.S. hospitalizations each year, and even short interruptions can mask atrial fibrillation, ventricular tachycardia, or transient pauses needing rapid intervention.

Unstable signals also increase false alarms and alarm fatigue, delaying response to true events.

Workflow burden reinforces the need. Clinicians must reposition electrodes, reconnect sensors, verify alarms, and troubleshoot dropouts, reducing efficiency and pulling attention from patient care. Many inpatient telemetry alarms reflect lead issues or motion artifact rather than physiology, creating noise and reducing trust in monitoring.

Veterinary settings add unique failure modes. Patients often chew, scratch, or pull at electrodes and leads, especially during recovery or stress. Clinical observations suggest 70%+ attempts to remove or chew monitoring components, causing signal gaps and equipment damage. Standard electrodes are poorly suited for fur, varied skin surfaces, and high mobility, increasing detachment and artifact. Technicians may need restraint, sedation, or frequent equipment replacement, slowing care.

Cost supports the need. In human hospitals, failures waste staff time and increase maintenance and verification. In veterinary hospitals, repeated replacement of chewed leads and damaged wires directly increases operating cost. Current ECG systems were designed mainly for humans and often lack durability, motion tolerance, and bite-resistant design, leaving a widespread gap across both care settings. Reducing dropouts, workflow disruption, and equipment damage would improve safety, efficiency, and continuity of care in human and veterinary hospitals.

IV. PROPOSED SOLUTION CONCEPT

To address the persistent problem of excessive wiring in the hospital environment, our team proposes the development of an onboard ECG processing unit that eliminates the need to transfer raw signals from the patient to a processing unit located outside the bed. This solution focuses on replacing the current out-of-bed processing unit used for 3-lead ECG monitoring, which is standard in ICUs and many other hospital settings.

The proposed solution is a wearable medical device consisting of a compact onboard processing unit integrated into a patch applied directly to the patient's chest. Three short wires extend from this unit and connect to the standard right arm (RA), left arm (LA), and left leg (LL) ECG leads. The wire lengths would be determined using statistical averages of electrode placement distances to ensure they are long enough to accommodate the anatomical needs of most patients without excess slack. The onboard processing unit would receive the ECG signals from the three leads, process them locally, and wirelessly transmit processed signal to a display integrated into hospital's existing patient monitoring system. A conceptual sketch of this device is shown in Figure 1.

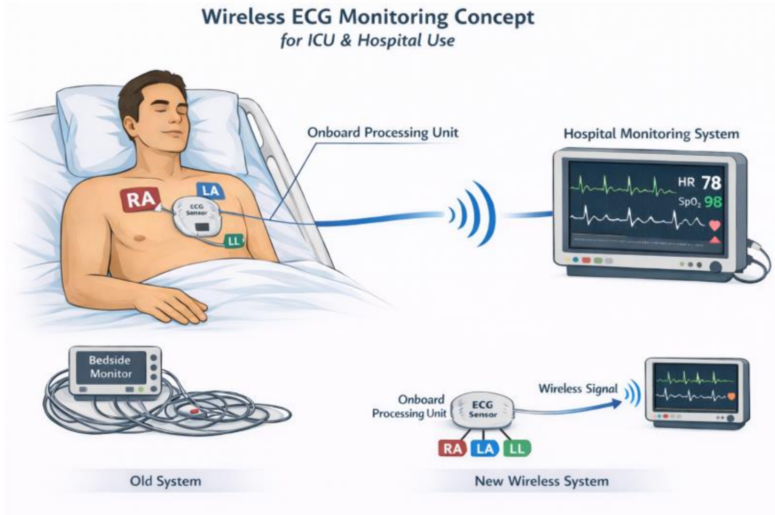

Figure 1: Conceptual Sketch of New Wireless ECG System

An additional key component of this redesigned system is an improved adhesive material for attaching the ECG leads to the patient. During clinical observations, poor adhesion was frequently noted as a major issue that negatively affected ECG signal quality and required repeated lead replacement. Improving adhesive performance would require further materials research; however, our team believes this improvement must be integral to the success of a wireless ECG system. Because wireless systems may be perceived as introducing additional points of failure, mitigating another common failure point - lead detachment - helps ensure reliable, continuous ECG monitoring. Current wearable medical devices, such as Dexcom and other continuous glucose monitors, utilize significantly larger adhesive surface areas than standard ECG leads. Further investigation into similar adhesive approaches could greatly enhance lead stability and reliability in the hospital environment.

This new approach to cardiac monitoring would primarily improve workflow efficiency for nurses in ICUs, but it would also benefit clinicians throughout the hospital. Nurses would still place the three ECG leads in anatomically appropriate locations and attach the onboard processing unit to a convenient location on the patient’s torso. After this initial setup, however, they would no longer need to manage long bedside wires. The stronger adhesive and elimination of wire snagging at the bed–environment interface would likely reduce the need for frequent lead reapplication, an issue commonly observed during clinical rotations.

This device is meaningfully different from existing ECG monitoring systems because current designs contribute to the “spaghetti” of wires at the bedside. These wires often interfere with patient mobility, complicate care tasks, and increase the risk of accidental disconnections. By relocating signal processing directly onto the patient and minimizing wire length, the proposed system reduces clutter, improves patient comfort, and streamlines clinical workflow. Further comparisons highlighting product differentiation can be found in the Value Proposition section.

V. FEASIBILITY COSIDERATIONS

This concept is realistic for a BIOM Senior Design project because it uses established ECG monitoring fundamentals while improving major clinical failure points: wire clutter, disconnections, motion artifact, and poor adhesion. A senior design team could build an early prototype showing reliable signal capture, onboard processing, and wireless transmission in a simulated clinical workflow.

Required technology is mature and widely available. Standard ECG electrodes (RA/LA/LL), low-noise analog front end, filtering and QRS detection, microcontroller, and wireless module can be built from commercial components. Form factor can use a compact rigid PCB in a small enclosure or a flex/rigid-flex layout to conform to the torso. Because the concept keeps standard lead placement, it fits current practice while reducing bedside wire length by using short leads. Key challenges include skin-safe materials, durable housing, strain relief at lead exits, and an adhesive system that withstands sweat, movement, and repositioning. For infection control, the most feasible approach is a single-use patient-contact adhesive patch paired with a reusable electronics module, or a sealed wipeable module with disposable electrode interfaces. Interoperability is a constraint: full integration with bedside monitors may require vendor-specific connectivity. Senior design can still demonstrate feasibility by transmitting to a gateway (phone/laptop) while defining requirements for monitor integration.

For human use, this device likely aligns with moderate-risk ECG monitoring and telemetry products and may follow a Class II 510(k) pathway using predicate devices with similar intended use. Key implications include electrical safety, electromagnetic compatibility, wireless reliability, and software expectations if processing or alarms are included. If positioned as an accessory that improves capture and transmits ECG to existing monitors, intended use may be clearer, but performance evidence remains essential. Veterinary deployment may require a separate commercialization plan and testing strategy due to fur, chewing, and housing durability needs. Primary safety goal is reducing missed arrhythmias and false alarms caused by artifact. Usability will drive success under time pressure. Design should minimize steps and placement errors through clear orientation, intuitive attachment, simple status indicators (connected, battery), and robust strain relief to prevent short-lead detachment during movement. Adhesive and skin-contact materials must reduce irritation, skin breakdown, and discomfort during prolonged wear. Because a core goal is lowering alarm fatigue, the system must avoid adding new alarms from unstable connectivity or noisy signals.

Main barriers include integration, adoption, and reliability in real environments. Hospitals may resist systems needing new receivers, IT support, or training. Wireless transmission must tolerate crowded clinical RF conditions, and cybersecurity/data handling adds complexity for deployment. Battery life must cover a shift or longer without frequent interruptions. Sweat, repositioning, bed transfers, and transport can reduce adhesion and signal quality. In veterinary settings, chewing and scratching increased risk, driving need for bite-resistant housings, alternative placement strategies, or stronger attachment methods. These risks are manageable but should guide prototype testing toward real failure modes, not ideal conditions.

In summary, the concept is feasible for senior design because a team can prototype acquisition, onboard processing, wireless transmission, and test performance against key failure points: adhesion, motion artifact, lead strain, and connection stability. With strong usability, a practical infection-control approach, and a realistic interoperability plan, the idea has a credible path toward deployment.

VI. IMPACT & VALUE PROPOSITION

The primary beneficiaries of a wireless ECG monitoring system are clinicians, particularly nurses in intensive care units, as well as patients and hospital systems. By addressing common challenges associated with traditional wired ECG monitoring, this solution provides measurable improvements in accuracy, usability, and workflow efficiency.

The most significant value of the proposed system is improved ECG accuracy and reliability. Conventional bedside ECG systems rely on long wires connecting the patient to an external processing unit, creating multiple points of failure due to disconnections, motion artifact, and electrical noise. By relocating signal processing directly onto the patient and eliminating excess wiring, the proposed system reduces signal interference and false alarms. In addition, improved adhesive materials for ECG leads help prevent lead detachment, a frequent issue observed during clinical rotations that often compromises data quality.

A second major benefit is time savings for clinical staff. Current ECG setups require frequent wire management and lead adjustments, increasing workload and cognitive burden for nurses. The wireless design allows clinicians to apply the ECG leads and onboard processing unit once, reducing the need for repeated adjustments and enabling nurses to focus on higher-priority patient care tasks.

Patients also benefit from increased comfort and safety. Reducing wires improves mobility, lowers the risk of accidental disconnections during repositioning or transport, and creates a less restrictive care environment. At the system level, these improvements may lead to indirect cost savings through reduced troubleshooting time, fewer non-actionable alarms, and more efficient use of clinical resources.

Overall, the proposed wireless ECG system delivers value by improving monitoring accuracy, reducing clinician workload, enhancing patient experience, and supporting safer, more efficient care delivery in hospital settings.

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