Study Protocol

Title: Feasibility of Wearables to Monitor Sleep, Activity, and Heart Rate in Older Adults Admitted in the Emergency Department

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Background: Emergency departments (EDs) increasingly serve as key points of care for frail older adults, many of whom experience prolonged stays due to a lack of access in inpatient ward beds. Frailty is associated with adverse outcomes including delirium, functional decline, falls, longer hospitalizations, and increased mortality. Yet clinical monitoring in the ED remains episodic with sparse data, typically relying on intermittent vital-sign checks and brief functional assessments. Critical physiologic and behavioral signals, such as sleep disruption, mobility, and heart-rate variability, are not continuously captured despite their relevance to delirium risk, deconditioning, and physiologic instability.

Wearable devices (e.g., wrist-worn accelerometers or smartwatches) have demonstrated feasibility in older adults in inpatient, post-acute, and community settings, and can reliably capture mobility, activity, and sleep/wake patterns, with acceptable accuracy reported in hospitalized patient populations.[1, 2] A structured review of older adult inpatients reported use of wearables to monitor physical activity and sleep, though methods across studies are heterogeneous.[3] Additionally, a usability study among older ED patients (mean age ≈ 77.6) found that participants could apply and charge the Apple Watch, although more advanced tasks (e.g., navigating complex screens or texting) were difficult.[4] We have evaluated Fitbit-derived heart rate (HR) against nurse-recorded clinical measurements in General Medicine patients and demonstrated good agreement, [1, 2] and have determined that sleep (particularly total sleep time) and activity are reliable in a recent study.[5]

Despite these developments, there remains a gap in systematic evaluation of the feasibility, data yield, and clinical interpretability of continuous wearable monitoring, including sleep, HR, and mobility, during the ED stay itself in frail older adults. This gap is particularly critical, given that the ED stay may represent a high-risk period for physiological instability, sleep disruption, immobility, delirium, and deconditioning. The Seniors Emergency Medicine Center (SEMC) is an ideal place to study whether wearable monitoring can complement existing clinical assessments.

This pilot project aims to address this gap by testing whether *continuous wearable data can be feasibly collected in older adults admitted in the ED* and whether these data provide interpretable signals that may augment meaningful clinical understanding of physiologic instability, sleep fragmentation, and mobility patterns during the ED stay.

Objectives

1. Primary Objective: Assess the feasibility and acceptability of collecting continuous physiological and activity data from older adults using a wrist-worn wearable device during ED admission.

2. Secondary Objectives:

- Quantify sleep duration, awakenings, heart-rate patterns, and mobility during the ED stay.
- Explore associations between wearable-derived signals (e.g., frequent nocturnal awakenings, prolonged immobility, tachycardia) and clinical outcomes (e.g., delirium onset, length of stay in ED, functional decline at discharge or short-term follow-up).

Methods

Study Design: Prospective feasibility pilot study conducted in the EDs of a large academic hospital network.

Population

- **Inclusion criteria:** Adults aged ≥ 70 years in the Emergency Department at TGH or TWH, admitted to Medicine or referred to Medicine and likely to be admitted
- **Exclusion criteria:** Skin conditions preventing wrist-worn devices, active agitation requiring restraints, or inability to consent and without an available substitute decision-maker.

Wearable Device: Fitbit Sense 2 capable of measuring: 1) continuous heart rate, 2) Step count, 3) Sleep/wake patterns (total sleep duration, wake-up count, rest/activity rhythm)

Procedures: Patients will be screened for eligibility and enrolled in study in ED. Baseline data, including demographics, comorbidities, medications, baseline mobility, frailty score, cognition, and usual sleep patterns, will be collected upon enrollment. A wrist-worn wearable will be applied with usage instructions provided. Device will be collected after wearing for 24 hours. Fitbit data will be extracted alongside

clinical chart data, including routine vital signs, nursing notes (e.g., mobility/toileting, sleep/rest observations), delirium assessments (if available), medications, and disposition. Upon device removal, a short survey will be administered to the patient (or caregiver) about comfort, device acceptability, and ease of use.

Outcomes

Feasibility outcomes:

- % of enrolled patients who wear device for ≥ 80% of ED stay via clock-time (between device placement and removal, excluding periods when removal is required for procedure/imaging); data completeness
- Proportion of devices with complete data (heart rate, activity, sleep)
- Acceptability (survey responses)

Exploratory clinical outcomes:

- Sleep metrics: total sleep time, number of awakenings, sleep efficiency, rest vs activity cycles
- Activity/mobility metrics: step count, hours active/immobile
- Heart rate metrics: average heart rate, episodes of tachycardia/bradycardia
- Associations between wearable-derived data: *frequent awakenings, immobility, abnormal heart rate* and clinical endpoints: *development of delirium, functional decline at discharge, disposition (home vs rehabilitation), length of stay*

Data Analysis

Descriptive statistics for feasibility outcomes (percent adherence, data completeness) with 95% confidence intervals. **Paired analyses** comparing wearable-derived data with chart-based data (where overlap exists). **Correlation analyses** (e.g., Spearman) between wearable metrics and clinical outcomes. **Exploratory regression models** (e.g., logistic regression for delirium outcome; linear regression for length-of-stay) to identify whether wearable-derived metrics independently predict outcomes, adjusting for baseline frailty, comorbidity, age, and presenting complaint. **Acceptability survey** results summarized descriptively.

Sample Size: With the aim to estimate adherence (e.g., proportion of patients with ≥80% wear) with a margin of error ±10% at 95% confidence, we need ~62 participants. To allow for 20% dropouts or unusable data (e.g., device removal), we propose enrolling 78 older ED patients.

Limitations: The largest limitation will be recruitment and consent challenges as patients may be acutely ill and/or cognitively impaired; we may need proxy consent. We will leverage our experience in recruiting strategies with hospitalized patients. Data may be incomplete if device is removed for care, imaging, hygiene, or during transfer; device loss is possible. Measurement accuracy may be limited in acute care settings, especially for sleep staging and step count in patients with low-mobility. Single-network pilot may limit generalizability. The impact of other SEMC interventions may affect activity or sleep, and so we will collect data on SEMC interventions for study participants. The pilot will not be statistically powered to detect associations between wearable signals and clinical outcomes (e.g., delirium, functional decline); these analyses remain exploratory and are intended to inform the design of larger follow-up studies.

Relevance and Expected Impact

This pilot addresses a critical evidence gap: whether continuous, unobtrusive physiologic and behavioral monitoring via wearables is feasible among older adults in the ED, and whether such data yield clinically meaningful insights. If successful, the study could:

- Lay the foundation for larger studies to examine whether wearable-derived signals predict adverse events (delirium, falls, deconditioning, delayed admission) in real-time.
- Inform ED geriatric care pathways (e.g., tailored interventions for patients with fragmented sleep, immobility, or tachycardia)
- Improve patient safety and outcomes by enabling early detection of deterioration or risk state — particularly for a vulnerable population often under-monitored.

Thus, this proposal could help bridge the gap between digital health innovation and geriatric emergency care, with long-term potential to improve morbidity and quality of care for frail older adults. This could be an exciting new avenue for Seniors Emergency Medicine Centre to measure and improve.

References

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