

# FUTURE BET #6: REMOTE PATIENT MONITORING



## VISION & GOALS

Over the past century, our approach to “vital signs” has remained virtually unchanged – requiring labor-intensive manual collection, interrupting our patient’s rest, and yet missing signs of deterioration between collection times. “It’s too much, yet it’s not enough,” said Dr. Sarah Fletcher, vice president and executive medical director of strategic innovation at Houston Methodist.

By adopting leading-edge sensors and wearable technologies, powered by clinical intelligence engines, Houston Methodist is poised to shift from a traditional episodic model of care to one that is more automated and continuous. This scalable approach to patient monitoring has the potential to:

- Streamline workflow
- Reduce hospital stays and costs
- Empower clinical teams and patients with highly actionable data
- Personalize care and improve patient experience

Using these technologies will ensure leading quality hospital care despite workforce challenges, and to better support patient recovery at home. Up to \$265 billion of care services could shift from traditional facilities to the home by 2025,<sup>1</sup> making remote care and continuous monitoring essential cornerstones of the Houston Methodist innovation strategy.



## OUR SOLUTION

Our continuous care model is designed around three tech-enabled approaches:

**(1) Medical grade multi-parameter wearables:** The FDA-cleared BioButton® medical wearable device is leading-edge biosensor technology. It passively captures high-frequency-trending vital signs from patients in general care units of the hospital, and ultimately at home.

**(2) Advanced algorithms and analytics:** Trending data and algorithmic-based alerting allow clinicians to identify early signs of patient deterioration, enabling proactive clinical interventions that may result in better care and patient safety.

**(3) Clinical intelligence and triage:** Clinical teams are empowered through exception management dashboards that display contextual patient data for more efficient, actionable clinical decisions.



## CURRENT RESULTS & PARTNERSHIPS

Houston Methodist has a portfolio of virtual care and monitoring technologies powering our clinical programs. Our strategic partnership with BioIntelliSense accelerates our care redesign and transformation efforts through a “hero product” allowing growth of our continuous patient monitoring programs that extends from in-hospital to home.

Throughout a patient’s hospital stay, the FDA-cleared BioButton® wearable medical device (about the size of silver dollar) automates the collection of vital signs by capturing up to 1,440 sets of vital sign measurements per day. Having high-frequency data flow for things like respiratory rate, heart rate, and temperature allows for identifying adverse trends at a fraction of the cost of traditional manual vital sign collection done four to six times per day.

Software solutions that use clinical intelligence aggregates robust data and provides clinicians with a composite view of patient vital sign trends, while simultaneously performing advanced analytics and alerting, for proactive clinical interventions and triage.

This end-to-end continuous care solution enables clinical teams to better detect early signs of patient deterioration or, conversely, identify stable patients who may be candidates for earlier hospital discharge.

The rechargeable BioButton device can be sent home with patient to continue monitoring of patients as they transition from higher to lower acuity settings, as part of an alternative to hospital stay or ER visit, or for better management of chronic conditions.



## NEXT STEPS

*We are actively implementing a four-stage plan to scale continuous patient monitoring in all system hospitals, then from in-patient to home as we integrate other devices and expand to many additional clinical use cases for the benefit of our team, our patients and the community we serve.*

<sup>1</sup> Bestsennyy O et al. From facility to home: How healthcare could shift by 2025. Feb. 1, 2023. mckinsey.com



# Continuous Patient Monitoring Command Center

Optimize clinical resources and better prioritize care



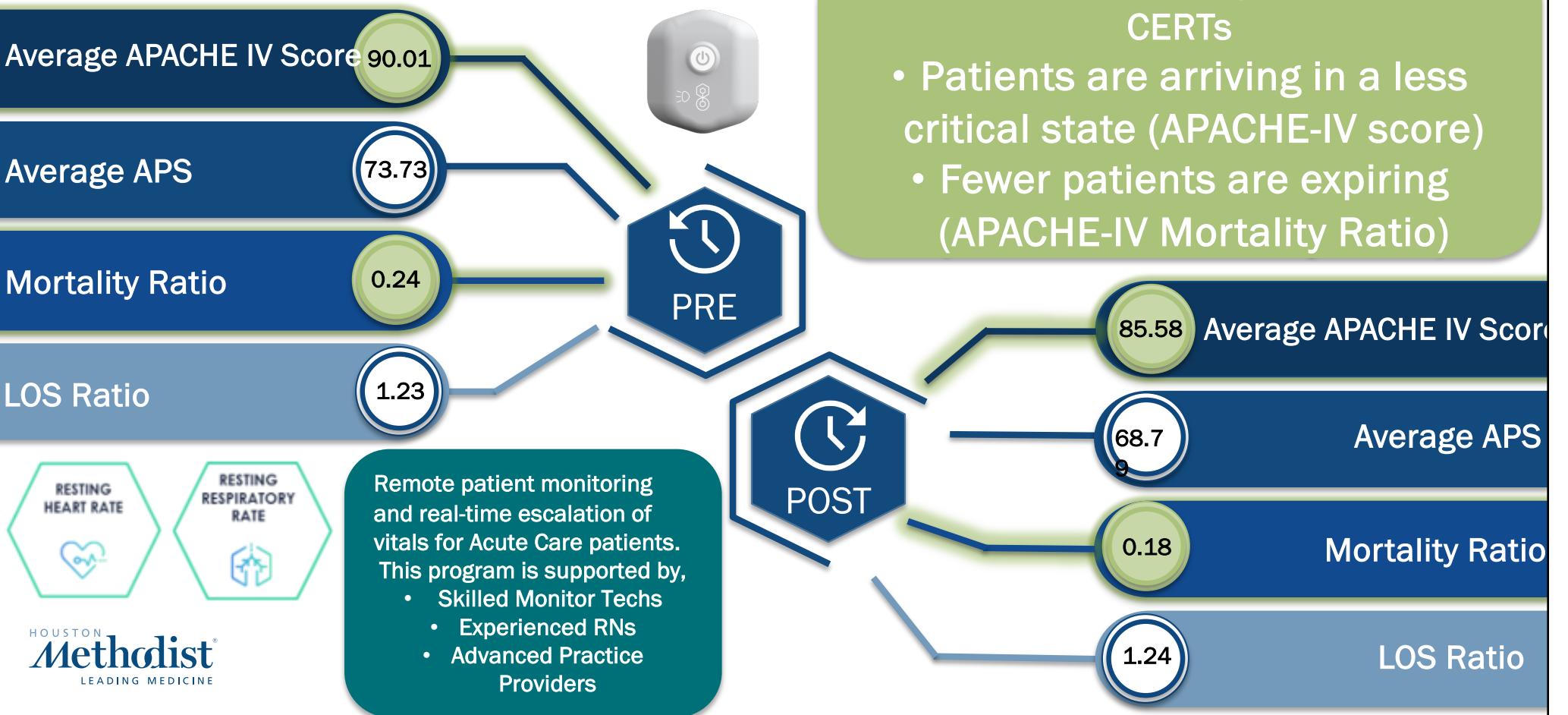
**400 BioButton patients** per monitoring tech  
**and 3 monitoring techs** (1200 patients) per nurse supervisor

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# CERT Patients that transfer to the ICU

## Pre and Post RPM with BioButtons®



# CERT Patients that transfer to the ICU

## Pre and Post RPM with BioButtons®

	PRE n= 656	POST n= 120
Average APACHE-IV Score	90.01	85.58
Average APS	73.73	68.79
Mortality Ratio	0.24	0.18
LOS Ratio	1.23	1.24

8 lives saved  
in this cohort  
alone

Early outcomes have shown that patients entering our ICUs via CERTs are arriving in a less critical state and fewer patients are expiring.

# Earlier Activation of Clinical Emergency Response Team (CERT) After Implementing Vital Sign Remote Patient Monitoring: Mortality Impact on Those Transferred to ICU

S. Homer, V. Narcisse, S. Klahn, L. Griffin, L. Randle, M. Gomez, A. Nguyen, B. Holderrand, G. Lee, and S. Pletcher

Houston Methodist Hospital

## Background/Introduction

Remote Patient Monitoring (RPM) has become vital in acute care, offering enhanced surveillance and early change in condition detection, especially when combined with other care redesign strategies. This study examines a cohort population (floor patients seen by CERT team who then transferred to the ICU) before and after implementation of an RPM program utilizing a wearable vital sign patch, "Biobutton" and related initiatives launched with a goal of improving clinical workflows, patient experience, and quality by leveraging digital health tools.

Setting - Quaternary urban teaching hospital in Houston, Texas

## Purpose/Objectives/Hypothesis

### Hypotheses:

- Higher frequency vital sign data, combined with monitoring algorithms and a 24/7 central team, escalating to bedside team and CERT team allows for earlier detection of patients with changing conditions, earlier assessment by bedside team, will reduce mortality for patients needing transfer to the ICU.
- Earlier intervention for patients needing transfer to ICU will be associated with a lower overall APACHE score in the POST population
- Proactive rounding by CERT team, triggered by predictive analytics and monitoring team escalations will be associated with a decrease in mortality for patients in study
- Extending bedside vital sign collection frequency (as allows more rest for stable patients and more time for bedside team to assess patients needing care) will not be associated with any increase in mortality for patients in study

### Purpose/Objectives/Hypothesis

- Do we see a difference in overall mortality for the population of patients requiring a CERT and ICU transfer from floor, before and after these care redesign programs introduced?
- How do APACHE-IV scores compare between the populations?
- Are the pre and post populations similar in terms of conditions and comorbidities?
- Do we see a difference in overall length of stay in this patient population before and after the implementations?

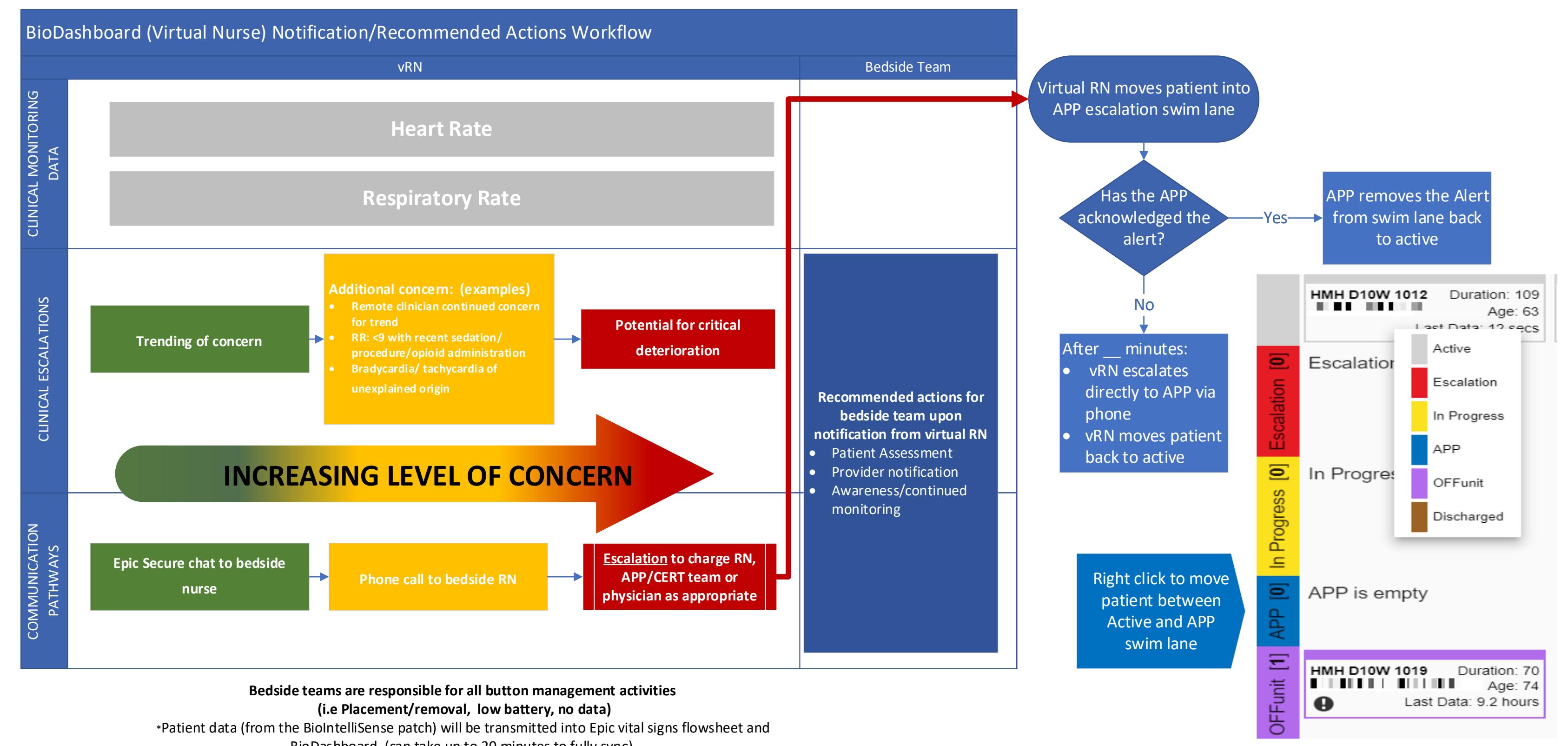
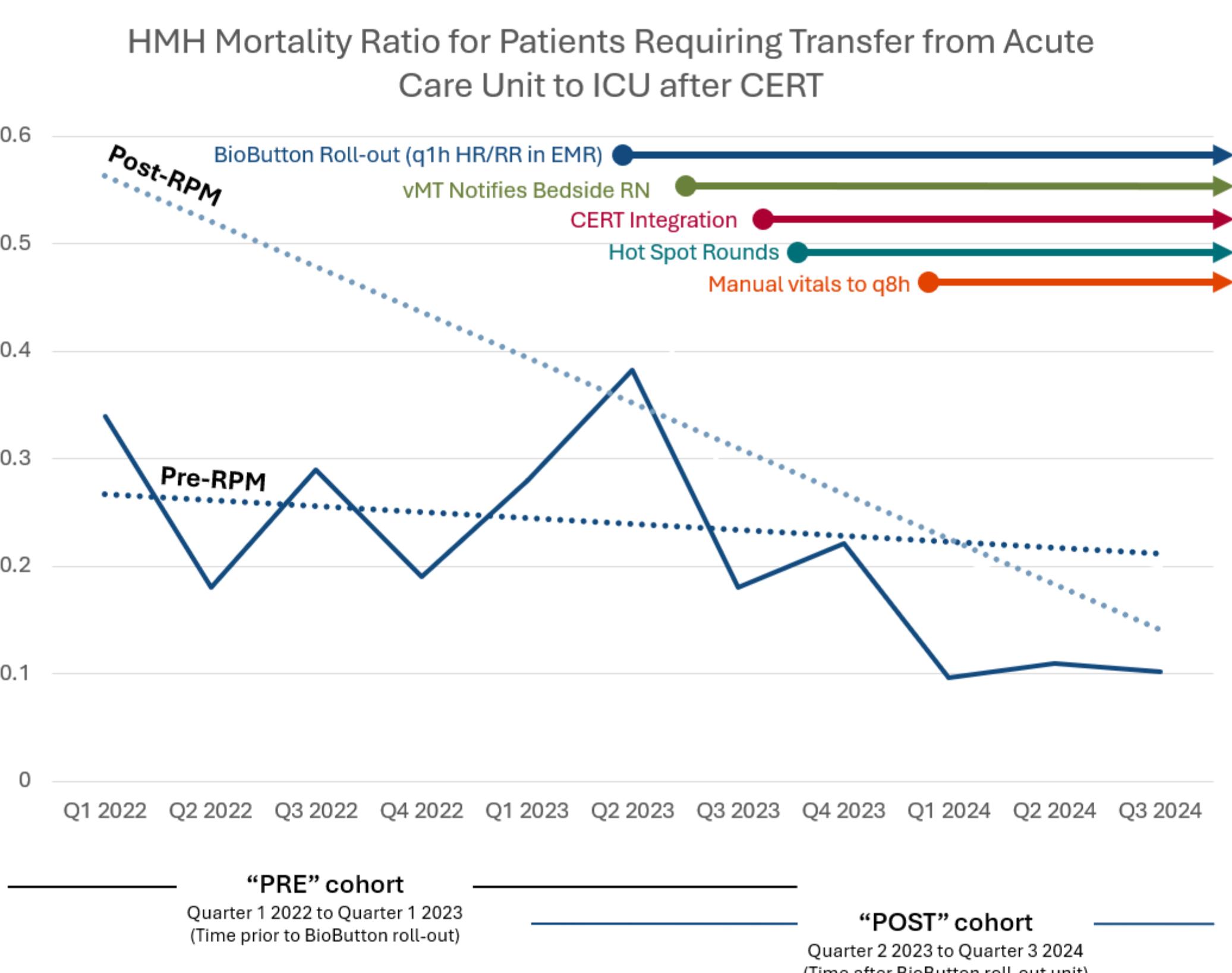
### Interventions included:

- Biobutton Implemented monitoring device on unit with hourly flow of vitals (HR, RR) into EMR flowsheet
- Monitoring Active monitoring of continuous vital sign data by virtual command center with escalations to bedside
- CERT referral Handoffs between clinical command center and CERT team to flag patients of additional concern
- "Hot spot" rounds CERT team "rounds" (EMR and bedside) on patients identified by analytics and monitoring team
- Vitals Redesign Routine bedside vitals frequency extended from q4 to q8+

## Methods

- Design
  - Observational retrospective data and chart review
- Patient Cohorts:
  - Divided into two groups: pre- and post-implementation of Remote Patient Monitoring (RPM)
  - Implementation of RPM was phased by units, so a pivot date was set for each unit based on go-live, with pre and post data collection windows being rolling, looking back for 23 months Pre and then 16 months POST. All units had gone live by 11/23. All POST patients were then combined into POST cohort, and all PRE patients were combined into PRE cohort.
  - The two cohorts were assessed by baseline comorbid conditions.
  - Pre-RPM Implementation: 1/1/22 – 11/30/23
  - Post-RPM Implementation: 4/1/23 – 7/30/24
  - Central monitoring with escalation/communication to bedside commenced in May 2023
  - CERT Nurse Practitioner (NP) integration with vMT workflow began on 9/1/23
  - Rollout and phasing varied by unit, with communication and training completed June 2023
  - Bedside vitals redesign started around January 2024.
- Methods
  - Retrospective Chart Review
    - Data Compared:
      - Biographical information
      - Comorbidity conditions
      - APACHE-IV scores
      - Mortality data
      - Length of stay
  - Chronic Comorbidity Condition Burden:
    - Comparison of pre- and post-implementation groups using billing codes to determine similar baseline rates of chronic diseases

## Results



	PRE n= 656	POST n= 464
Average APACHE-IV Score	90.01	83.96
Average APS	73.73	67.76
Mortality Ratio	0.24	0.20
LOS Ratio	1.23	1.09

18 lives saved in this cohort alone

## Results/Implications

### Results

In the patient populations who were on medical-surgical nursing units and required CERT team evaluation & were transferred to ICU units before and after implementation of RPM, we observed:

- Lower APACHE-IV score at ICU entry after RPM than before
- Similar ICU LOS after RPM compared to before
- Lower Mortality after RPM compared to before

### Implications

- Early outcomes have shown that patients entering our ICUs via CERTS are arriving in a less critical state and fewer patients are expiring.
- 18 lives saved in this cohort alone.
- Integrating RPM into high-frequency monitoring offers an efficient approach for large hospitals promising enhanced patient safety.
- Reducing bedside vitals sign collection, when paired with enhanced surveillance through wearable RPM, is not associated with an increase in mortality

## Future Actions

With the benefit of an unprecedented database of high frequency physiologic data about hospitalized patients, program development opportunities are abundant. The hospital vitals monitoring program roadmap includes enhanced monitoring analytics (incorporating more insight from EMR into protocols), more precision (development of alerts based on patient cohorts), more prediction, and additional collaboration development with bedside and virtual care teams. Additional, work is underway to implement devices and monitoring capabilities into care for patients leaving the hospital, emergency department, or needing support for acute and chronic conditions while at home.

Further research is needed to determine the impact on outcomes of the different components included in the interventions described in this study: higher frequency data availability, objective respiratory rate measurement, hourly RPM data feed into EMR deterioration indices, the various algorithms within the alerting software, the use of a dedicated central clinical monitoring team, and communication to bedside team, providers, and CERT teams.

## Acknowledgments

The innovation team, executive leadership across the system, clinical teams from vMT and CERT as well as countless nurses and PCAs on the acute care floors have been immeasurably helpful in our obsession with implementing digital health technology for the best and safest care.

## References

- Areia, C., Biggs, C., Santos, M. et al. The impact of wearable continuous vital sign monitoring on deterioration detection and clinical outcomes in hospitalised patients: a systematic review and meta-analysis. *Crit Care* 25, 351 (2021). <https://doi.org/10.1186/s13054-021-03766-4>