



Detecting Deterioration Early:

How Continuous Vital Signs Monitoring Enables Proactive Health and Wellness Care

The Hidden Potential of Vital Signs

The practice of monitoring vital signs is an age-old ritual, virtually unchanged over the years save for the advent of medical devices to aid in precision and ease of measurement. Vital signs provide a simple way to understand an individual's current clinical condition and detect acute changes that may require intervention¹. But beyond this, vital signs can tell us much more than just how "sick" someone is. By learning how each person's heart and lungs function each and every day, caregivers can begin to understand their baseline health and well-being, their response to interventions and more effectively respond to changes in their condition.

While it is generally agreed that the frequency of vital signs collection should be individualized and that "more is more", best practice guidelines and standards of care are ultimately limited by logistical and operational challenges within any given care setting². The perceived stability of patients, the types and ratios of existing clinical staff, and perceptions around the "value" of monitoring for chronic conditions all impact how much clinical oversight and monitoring takes place.

Long-Term Care (LTC) facilities, where patients (residents) are expected to be more stable and have chronic (versus acute) care needs, are typically staffed with fewer clinicians, many of whom have a narrower scope of practice. While staffing levels within the LTC industry have been historically fragile, the Covid-19 pandemic pushed shortages to critical levels, driven by high turnover, mass resignations and unprecedented levels of staff burnout.^{3,4} With patient complexity rising, their vulnerability to illness and death has become evident, particularly in the context of underlying frailty, complex medical conditions, and congregate living^{5,6}.

Simply put, monitoring and understanding vital signs has never been more important, but there has historically never been enough staff, time or available solutions to measure as frequently as we want.

This perfect storm of reduced staffing, higher acuity and greater vulnerability, has meant the ability to capture and utilize in-depth vital sign information to monitor illness, detect deterioration and promote wellness has been out of reach for many, particularly in post acute or chronic care settings. Subtle early clues of impending deterioration are easily missed, and for many individuals in these settings, reactive interventions and urgent transfer to hospital are often the only options if their condition takes a turn for the worse.

Using Vital Signs to Predict Deterioration

While there are five standard measurements that encompass a "complete" set of vital signs (heart rate (HR), respiratory rate (RR), temperature, blood pressure (BP) and oxygen saturation (SPO₂)), **RR and HR are widely validated as the two strongest early predictors of clinical deterioration⁷**, due to their sensitivity in responding to a variety of clinical and pathological conditions⁸.



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Despite its powerful predictive capability, RR has historically been an undervalued and inaccurately reported measure. RR is notoriously time-consuming and challenging to measure, so it is often simply omitted, leading researchers to refer to RR as the “neglected vital sign”⁹. SPO₂, mainly collected during intermittent vitals measurements has become more widely used as an overall representation of breathing status. However, there is a critical distinction: RR is a measure of ventilation (air exchange in the lungs), while SPO₂ measures oxygen saturation (how much oxygen is in the blood)¹⁰.

Relying only on SPO₂ can provide a false sense of security for staff as patients who are deteriorating may have SPO₂ within normal range as the body attempts to compensate by increasing RR. **Changes in SPO₂ may not be evident until increases in RR fail to adequately compensate for inadequate gas exchange in the lungs.** The lack of reliable RR measurements and a dependence on SPO₂ means that the signs and signals of early deterioration may either be missed altogether or detected too late to enable timely intervention^{10,11}.

INCREASING RESPIRATORY RATE

May be a potential indication of acute illness, hyperthyroidism, respiratory distress or medication side-effects

INCREASING HEART RATE

Potential indication of cardiac failure, fever, pain, distress or sepsis symptoms, shock states

DECREASING RESPIRATORY RATE

Potential indication of medication induced respiratory depression, sleep apnea

DECREASING HEART RATE

Potential indication of hypothermia, CNS depression, hypothyroidism, heart block or shock states

70-80% **OF PATIENTS** HAVE ELEVATED OR DEPRESSED VITALS AT LEAST 6 HRS BEFORE EVENT¹²

Why Continuous Monitoring?

Continuous vital signs monitoring is the gold-standard in higher acuity settings like Intensive Care Units (ICU), where low patient-nurse ratios enable clinicians closely watch for subtle changes signaling an impending deterioration and the need for urgent intervention. The effectiveness of continuous monitoring at detecting deterioration is well established¹³, and in fact, consensus was received at a 2010 resuscitation conference that “if practical and affordable, all patients should be monitored continuously”¹⁴. Unfortunately, most existing solutions limit patient mobility or require intensive nursing oversight, effectively rendering the practice impractical in lower acuity settings.



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As such, researchers have attempted to investigate alternative continuous monitoring solutions that offer similar clinical benefits outside the ICU using “wearables” such as patches, wristbands, or rings. These efforts have seen mixed success, with the availability of more frequent vital signs data being well received but the utility ultimately limited by varied patient satisfaction, user compliance and inconsistent use¹⁵. In the post-acute space, consumer grade wearable devices may lack the detail or accuracy required for clinical-level monitoring and treatment decisions.

Recognizing that early detection of deterioration can reduce acute care transfers and the risk of poor outcomes, researchers across the globe have created a number of Early Warning Scores (EWS); algorithms that utilize a combination of patient factors and clinical data from the medical record to estimate risk of deterioration and in some cases, trigger care pathways and interventions¹⁶. While EWS offer promising clinical utility, they are naturally limited by the historical challenges in quality and frequency of data inputted to drive their algorithms. Therefore, to optimize predictive strength of these clinical tools, we need to optimize the strength of data being fed into them.

Using Autonomous Contact Free Continuous Monitoring (A-CFCM)

New and emerging tech solutions aimed at optimizing vital signs collection to enhance clinical care must be robust enough to provide accurate, consistent, and reliable clinical data yet flexible enough to function within the existing operational, resident and environmental limitations. Solutions that require additional nursing time, input or patient/resident cooperation will undoubtedly fall short either on accuracy or compliance – or both.

The use of radar-based technology, such as Xandar Kardian's recently launched **XK-300, have shown high performance and the ability to overcome the barriers of their predecessors**. These sensors monitor RR and HR through the interpretation of micro and nano-vibrations emitted from the human body at rest. Sensors installed on the ceiling or over the head of the bed measure vital signs continuously and without the need for patient compliance - providing the benefits of detailed, accurate information without disrupting patients or requiring additional effort on the part of staff. Moreover, sensor data can be monitored remotely, enabling acute-level health and wellness monitoring across the entire care spectrum: from acute, inpatient units, to post acute settings, residential care facilities and private homes. With data provided continuously, clinicians can access accurate and detailed baseline and trending vital signs for clear information on individual status and early detection of deterioration.

“Nurses rely on their assessment skills, knowledge, and judgement to identify changes in condition and prioritize care; having access to trends based on real-time information on patient status is another powerful tool to enhance clinical decision making and identify the need to intervene earlier.”

- Susan Coppola, RN, BS



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Case Study: Capturing Deterioration Sooner

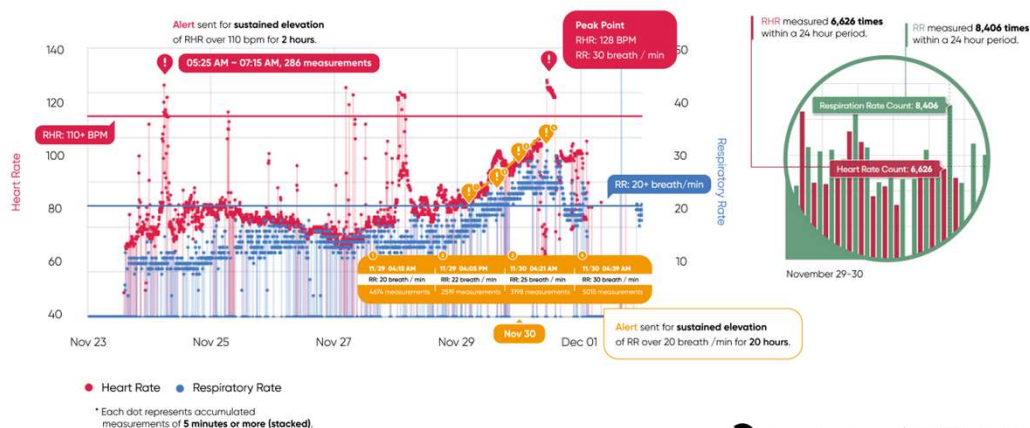
The predictive capability of the Xandar Kardian XK300 continuous vital signs monitor was demonstrated at a Skilled Nursing Facility in New York. On November 24th, the vital signs of an 89 year-old resident began showing unusual intermittent changes: prolonged spikes in her resting heart rate to 125 bpm, while her respiratory rate remained stable.

SNF Pilot Case Study (Nov. ~ Dec. 2021)

Location: New York

Resident: 89 Years Old / Female

Early intervention via predictive health through autonomous, continuous, contact-free monitoring.



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In the days that followed, these spikes re-emerged, and on November 29th both her resting heart and respiratory rates began to demonstrate worsening, sustained elevations, ultimately peaking two days later with her heart rate pumping at 128 beats/min and her respiratory rate at an alarming 30 breaths/min. Unfortunately, these changes culminated in rapid respiratory and cardiac decline suggestive of acute collapse and this resident was transferred to hospital.

The intermittent nature of traditional vital signs monitoring means that unusual or early changes in condition are often not captured, and the opportunity to intervene is easily missed. Only by capturing and observing this resident's vital signs continuously over time, could these gradual changes in her heart and respiratory rate be contextualized and clearly identified as a departure from her baseline.

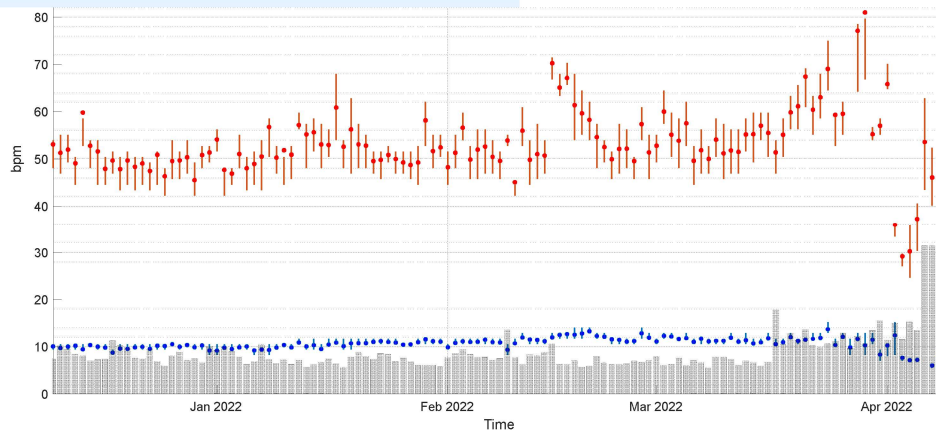
A review of the subtle changes in vital signs that were captured by the Xandar Kardian device in the days prior to acute deterioration highlight the predictive capability of continuous vital signs monitoring and validate radar-based monitoring as a powerful tool to improve patient and resident outcomes through early detection and intervention.



XANDAR KARDIAN

Case Study: Maggie's Story

Maggie was an 88 year-old female years old living with Alzheimer's Disease in a residential hospice facility when her family started continuous vital signs monitoring using the Xandar Kardian XK300 device. As Maggie was no longer able to speak, her family was eager to ensure she was comfortable and that caregivers could respond to her needs every day.



Maggie's vital signs demonstrated consistent patterns each day during the first few months, and when the family noted unusual spikes in her resting heart rate, they discussed it with the facility staff. "It turned out that Mom was having regular periods of anxiety around feeding and changing, which was causing her heart rate to rise. We worked with the clinical team, who implemented distraction and calming interventions that they could use to ease her anxiety before it could peak" noted her son.

The following month, more substantive changes to her vital signs were detected: a rise in her baseline heart rate, combined with irregular respiratory patterns and an increase in movement index.

Three days prior to her death, the XK300 sensor detected acute changes in her vital signs patterns suggesting that her end of life may be near. Her son notified the family and immediately came to her bedside, spending the remaining few days and hours with her, providing comfort measures and ensuring her final wishes were honoured.

"From a clinical perspective remote monitoring speaks for itself, but from a family perspective, knowing her care and suffering was being continuously monitored and managed was priceless, especially during an emotional time when we all felt helpless." Maggie's Son



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Changing the Standard of Care

Vital signs offer a simple and valuable mechanism to understand health and predict deterioration. However, their predictive capabilities in settings outside the ICU have been limited by the intermittent nature of traditional vital signs collection methods and the poor reliability of critical measurements such as RR. Efforts to improve prediction through continuous monitoring using wearables have been hindered by their high demands on staff, restrictions for patients or residents, and the limitations and intrusiveness of devices themselves. Newly developed radar-based vital signs devices, like the Xandar Kardian XK300, offer continuous, clinically validated, and reliable resting HR and RR data without additional effort, expertise or compliance from patients, residents or staff in any setting.

*Better Information. Strengthen Prediction.
Improve Patient Outcomes.*



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