



General medicine

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Intelligent patient monitoring with digital healthcare technologies

Abstract

Early interventions can help prevent poor outcomes in patients, thereby reducing associated cost-intensive treatments required for their management. There is a need for long-term and sustainable solutions that aid the continuous monitoring of patients and help clinicians and nurses address changes in patients' health in a timely manner. In today's digital era, technology is transforming many areas of our lives, and humanized technologies, such as telemedicine, mobile health, electronic health records, and artificial intelligence, have the potential to revolutionize individualized patient care. Extending continuous patient monitoring outside of the critical care setting using digital healthcare solutions can facilitate systematic disease monitoring and improve clinical outcomes.

Introduction

Advances in healthcare indicate a positive development. However, as the aging population increases, more resources are required to support health maintenance, disease prevention and disease management.¹ Consequently, this requires a heavier use of healthcare resources.^{1,2} However, a mismatch between the need for healthcare resources required to meet the rising patient burden, and their actual availability,

puts a strain on existing resources and staff.² This can, in turn, affect the quality of patient care³ and the revenue of hospitals. Moreover, staffing shortages and conventional methods of intermittent collection of vital signs and manual documentation can lead to inefficiencies, increased workload, and burnout in healthcare professionals.^{4,5}

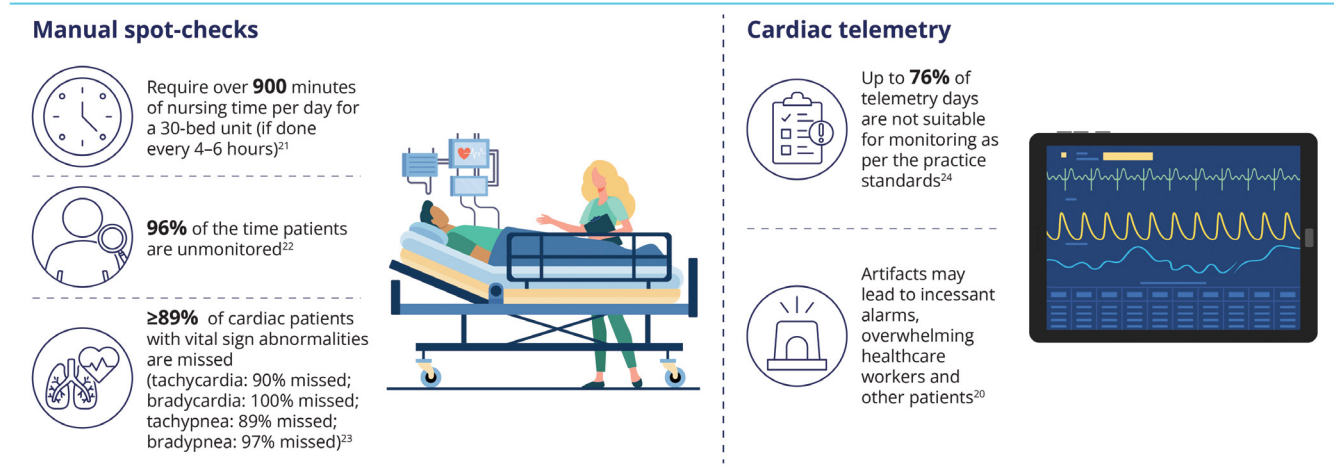
Common challenges encountered in healthcare settings

Complex workflows, increased workload, and stress on existing personnel

Following the COVID-19 pandemic, public health issues have reached new heights.⁶ Several healthcare protocols have undergone transitions, including the shift from ambulatory care to virtual telemedicine platforms.⁷ Clinicians spend a significant amount of time completing clinical documentation, and adopting the right technology reduces documentation time, leading to a decrease in burnout.^{8–10} Moreover, many hospitals are facing staffing shortages and high attrition rates, leading to an increased workload. Several factors may lead healthcare professionals to consider leaving their organization, including lower compensation, excessive administrative workload, and burnout.¹ The increase in healthcare workers leaving their organizations can put tremendous



Figure 1. Challenges and limitations of traditional monitoring methods like manual-spot checking²¹⁻²³ and cardiac telemetry^{20,24}



pressure on hiring managers and decision-makers to attract and retain experienced clinicians.⁹

Shortage of resources and workforce

An increase in hospitalizations, readmissions, and patient acuity with workforce shortage brings added pressure to hospitals and health systems finances and may put patients at risk.¹¹

Changing needs and transitions in patient care

Continuous monitoring of vital patient parameters, such as body temperature, heart rate, and respiratory rate, plays a key role in the timely detection, prevention, and treatment of cardiac and respiratory adverse events (AEs) in hospitalized patients.^{12–15} Patients in intensive care units are monitored continuously; however, patients are monitored intermittently once they are moved to the general ward, although their risk of postoperative AEs remains high.^{16,17} Changes in vital signs often precede AEs in hospital wards.¹⁸ However, conventional methods of patient monitoring, including manual spot-checking by nurses, can have practical limitations in large clinical settings. Furthermore, traditional methods, including cardiac telemetry, used to monitor changes in heart rate, are costly, frequently overused,

and contribute to longer hospital stays.¹⁹ Additionally, artifacts recorded via telemetry may lead to incessant alarms, which may overwhelm healthcare workers and other patients.^{13,20}

To overcome these challenges, healthcare providers are increasingly adapting to a paradigm shift that emphasizes systematic monitoring and patient-centered and individualized care.¹ In this regard, digital health technologies have the potential to transform patient monitoring and disease management, particularly in regions with limited resources.¹ By integrating data related to vital signs, medical history, and lifestyle, digital health applications, including telemedicine, mobile health apps, wearable devices, electronic health records, and artificial intelligence, might help build a patient-centric and personalized medicine model.^{25–27}

Modern continuous monitoring devices

One example of the technology available for continuous patient monitoring is HealthCast™ intelligent patient monitoring from Medtronic, a portfolio of remote monitoring, connectivity, and interoperable solutions that aims to help optimize

clinical workflows, clinician efficiency, and patient safety.²⁸ The portfolio automatically integrates patient data into electronic medical records (EMRs), which can aid patient management and clinical outcomes.³⁰

The portfolio comprises the BioButton® multi-parameter wearable device, providing trending data of respiratory rate at rest, heart rate at rest, and skin temperature along with a broad range of other biometrics in hospitals and at home, HealthCast™ Vital Sync™ remote patient monitoring, a system enabling clinicians to monitor patient data from anywhere in the hospital so that they can respond proactively, also providing direct EMR connectivity, and HealthCast™ services, which support device connectivity to hospital systems, including EMR, and offer continued support to those using these tools.

The insights served by continuous monitoring devices guide clinicians to intervene early, tailor treatment plans, and, crucially, reduce their workload.

Ways in which clinicians and nurses can benefit from remote monitoring technologies

Streamlined documentation processes, optimization of workflows, and a reduction in burnout



Automated monitoring and EMR integration of patient data through technologies such as HealthCast™ VitalSync™ remote patient monitoring saves the documentation time usually required to manually enter patient data into the system (25,300 hours saved annually)³⁰, which can be redirected towards meaningful patient interactions and crucial decision-making and may also reduce clinician workload and the likelihood of burnout.³¹ Moreover, real-time insights and timely alerts from continuous monitoring devices facilitate a more proactive response and can be accessed by empowered clinicians remotely.

Efficient patient monitoring

Subtle changes in vital signs, which can be early indicators of deterioration, can be missed between manual spot-checks, impeding timely prevention and treatment of AEs. Continuous monitoring supports an accurate and timely response.³²

Clinically actionable notifications without alarm fatigue

Frequent notifications and alarms from manual monitoring systems can lead to alarm fatigue. Continuous remote monitoring delivers clinically relevant notifications, which ensure that clinicians respond promptly to genuine alerts without being overwhelmed by unnecessary alarms.¹³

Prioritized patient care and triage resources

Owing to staffing shortages, it may be difficult for clinicians to monitor all patients in the general ward to the same degree. In such a scenario, it is important to address high-risk patients with priority. Manual monitoring of vital signs may lead to a lag in the management of emergent patients. In such cases, automated multi-parameter monitoring using applications such as the BioButton® provides trends in patient data, which

can serve as a triage tool for risk stratification of patients. Through using this data, clinicians can prioritize patients who need urgent care, and efficiently allocate time and resources, as well as use trending patient data to identify who they can let rest or who they can confidently discharge.

Advantages of continuous patient monitoring technologies in hospitals

Deployment of continuous remote monitoring technologies can lead to:

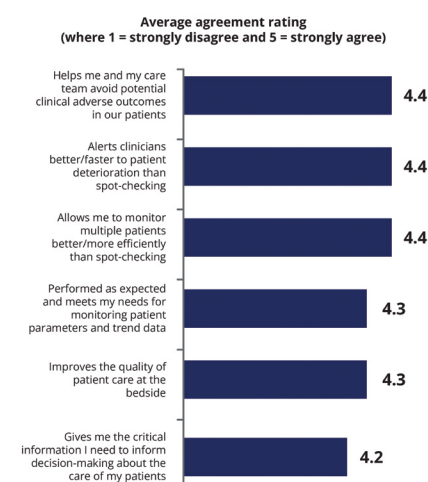
- A shorter average hospital stay³³
- Fewer unplanned ICU admissions^{14,34,35}
- Fewer rapid response team activations^{14,34,35}
- Decrease in complication rates³⁵

Continuous patient monitoring devices, including the BioButton® multi-parameter wearable, provide clinical insights and changing trends in patient data, which can reassure clinicians and patients in between in-person assessments. While continuous patient monitoring is already widely practiced, there are some gaps that must be addressed, such as the standardization of vital sign measurement and the description of vital sign observation methods.⁵ Notably, early warning scores help clinicians recognize deterioration 6–8 hours before code blue (cardiac or respiratory failure) in a vast majority of cases.³⁶ Continuous monitoring of patient data provides accurate early warning scores which might help clinical staff stratify and manage high-risk patients efficiently.^{14,32} These improved outcomes might help hospitals effectively manage capacity and support patient safety.

Extension of patient care beyond the hospital

The benefits of continuous remote monitoring extend largely beyond the hospital's doorstep. Extending patient care to the home environment with

Figure 2. Overall performance of the Vital Sync™ VPMP. Adapted from Torr, M. Vital Sync™ post-market clinical follow-up survey results. Medtronic and Purdie Pascoe white paper. US-PM-2200342. November 2022.²⁹



wearable devices can enhance patient satisfaction as they remain connected to healthcare professionals, ultimately contributing to lower readmission rates.³⁷ Moreover, the option of remote monitoring reassures clinicians that they are aware of any changes in the patient's health and gives them confidence in allowing patients transitioning from hospital-to-home (first 30 days) to stay in the comfort of their own surroundings.³⁸ Furthermore, abnormalities in patient trends may be escalated to plan a home visit or have the patient visit the clinic to initiate appropriate interventions.³⁷

It is important for corporations developing continuous monitoring devices to prioritize technologies that do not hamper the daily activities of the patient to ensure compliance. The BioButton® wearable is one such device that can be discreetly worn on the left upper region of the chest, whilst it tracks and collects over 1,440 vital sign measurements per day, and can be used for at-home monitoring, while allowing free movement.



Conclusions

- The ever-increasing patient burden and shortage of hospital staff and resources can collectively hamper the quality of patient care and productivity.³
- Traditional methods of patient monitoring, including intermittent spot-checks, are limited in terms of manual entry of patient data, which is time-consuming and inefficient.²¹
- Digital healthcare technologies, including wearable devices and mobile health applications, facilitate remote and continuous monitoring of patients' physiological parameters, such as respiratory rate, heart rate, and temperature, and integrate patient data directly into EMRs. Clinicians and nurses can access the data remotely, respond promptly to changes in patient vitals, and implement timely measures.¹²
- Automated monitoring saves time and resources which can be allocated towards more critical patients, and can decrease burnout among clinicians and nurses while enhancing their work satisfaction and empowerment.³¹
- In-home monitoring with digital technologies can significantly decrease hospital readmissions, unplanned ICU admissions, rapid response, postoperative AEs, and patient mortality.³⁷

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