Article

Vital signs monitoring on general wards: clinical staff perceptions of current practices and the planned introduction of continuous monitoring technology

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Abstract

Objective: Early detection of patient deterioration and prevention of adverse events are key challenges to patient safety. This study investigated clinical staff perceptions of current monitoring practices and the planned introduction of continuous monitoring devices on general wards.

Design: Multi-method study comprising structured surveys, in-depth interviews and device trial with log book feedback.

Setting: Two general wards in a large urban teaching hospital in Sydney, Australia.

Participants: Respiratory and neurosurgery nursing staff and two doctors.

Results: Nurses were confident about their abilities to identify patients at risk of deterioration, using a combination of vital signs and visual assessment. There were concerns about the accuracy of current vital signs monitoring equipment and frequency of intermittent observation. Both the nurses and the doctors were enthusiastic about the prospect of continuous monitoring and perceived it would allow earlier identification of patient deterioration; provide reassurance to patients; and support interdisciplinary communication. There were also reservations about continuous monitoring, including potential decrease in bedside nurse–patient interactions; increase in inappropriate escalations of patient care; and discomfort to patients.

Conclusions: While continuous monitoring devices were seen as a potentially positive tool to support the identification of patient deterioration, drawbacks, such as the potential for reduced patient contact, revealed key areas that will require close surveillance following the implementation of devices. Training and improved interdisciplinary communication were identified as key requisites for successful implementation.

Key words: monitoring, physiological, hospitals, general wards, patient safety, evaluation studies as topic
Introduction

Monitoring vital signs is integral to patient care in acute hospitals [1]. Traditionally, the five vital signs are blood pressure (BP), pulse, respiratory rate, oxygen saturation (SpO2) and temperature [2]. These signs are universally used to monitor patients’ progress. Changing trends in patients’ vital signs data can indicate clinical deterioration, which, without identification and intervention, can lead to adverse consequences or death [3, 4]. Rapid response systems (RRSs) enable escalation of care to a medical emergency team (MET) when patients’ vital signs breach accepted thresholds. These systems have been implemented in many countries and have reduced the incidence of deaths and cardiac arrests in acute hospitals [5–7]. However, the success of RRSs is reliant on timely vital signs data and identification of deterioration [8]. Yet, recent research shows that the monitoring and recording of the five vital signs is often incomplete which poses the potential to miss deterioration [9].

The patient casemix on general wards has changed over recent decades, with patients now older, more acutely ill, experiencing more co-morbidities and facing complex procedures [10–12]. Yet, general ward patients are still monitored in much the same way as they have for over a century; with nurses intermittently measuring and recording vital signs. Moreover, the frequency of recording varies, with limited evidence to suggest the most effective frequency for measurement [13]. Continuous monitoring technologies are a more proactive approach to the early detection of patient deterioration and have been reported as potentially enhancing early identification of deteriorating patients [14]. There is limited research, however, that assesses clinical staff perceptions regarding patient monitoring and the potential impact of continuous monitoring on practices.

As part of a larger project aimed at improving safety through timely recognition of deterioration, this study conducted a formative evaluation to assess perceptions of the implementation of continuous monitoring devices on general wards. Formative evaluation in the early stages of technology implementation projects has been advocated as means to inform feasibility, provide opportunities for iterative assessments of intervention viability, guide the development and refinement of interventions, and characterize success factors in the quest to optimize patient safety [15, 16].

Objectives

The aim of this study was to investigate clinical staff perceptions of current monitoring practices and the planned introduction of continuous monitoring devices on general wards. The study objectives were to

(i) assess nurses’ knowledge and confidence regarding current vital signs monitoring tools and practices;
(ii) gauge doctors’ and nurses’ perceptions regarding introduction of continuous monitoring devices;
(iii) obtain staff feedback on issues identified while wearing the continuous monitoring devices; and
(iv) investigate interdisciplinary communication regarding patient deterioration and care.

Methods

We undertook a multi-method study comprising structured surveys, in-depth interviews and log books (Table 1). These activities were conducted between January and August 2014 on two wards (respiratory and neurosurgery) of a large teaching hospital in Sydney, Australia.

Prior to commencing the research, we held briefing sessions for staff to explain the study purpose and provide a demonstration of the continuous monitoring devices. The ‘ViSi Mobile’ monitors (Sotera Wireless, California) are wrist-worn wireless mobile devices that capture continuous information on non-invasive BP, pulse, respiratory rate, SpO2, skin temperature and electrocardiogram rhythms [17]. Vital signs data are shown on the device display and are also wirelessly transmitted to a remote viewing display (e.g. a desktop computer).

The study was approved by the local Health District ethics committee (approval reference HREC/13/LPOOL/357). We used a reciprocity framework, whereby clinical staff perceptions were regarded as authoritative and central to the research, and we fed back study findings to ensure reliability of the obtained data [18]. In line with the reciprocity framework, we provided all clinical staff the opportunity to participate in one or more research activities. Participation was voluntary and consent was obtained from staff prior to their participation in each research activity.

Knowledge survey

A structured survey (Table 2), relating to confidence in vital signs monitoring tools and practices, was verbally administered to 33 nurses. The researcher provided statements and asked respondents to indicate whether they strongly agreed, agreed, were uncertain, or disagreed.

<table>
<thead>
<tr>
<th>Table 1 Research activity, aim, and number and rate of participation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Research activity</strong></td>
</tr>
<tr>
<td>Knowledge survey</td>
</tr>
<tr>
<td>In-depth interviews</td>
</tr>
<tr>
<td>Device trial and log book</td>
</tr>
<tr>
<td>Communication survey</td>
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</tbody>
</table>

*There were 40 respiratory ward and 41 neurosurgery ward nurses (total 81 nurses). All were eligible to participate in the in-depth interviews, device trial/ log book and communications questionnaire. For the knowledge survey, the nursing unit manager(s), clinical nurse consultant and clinical nurse educator were not eligible. Thus, 36 respiratory ward and 38 neurosurgery ward nurses (total 74 nurses) were eligible to participate in the knowledge survey.

bThe 10 participants constituted 8 nurses and 2 doctors.

cThe participation rate reflects the eight nurses who participated in the interviews.
disagreed or strongly disagreed with each statement. Data from the survey were analysed in SPSS (IBM SPSS Statistics 22) applying descriptive statistics.

In-depth interviews
Structured in-depth interviews (Table 3) aimed at gauging perceptions regarding benefits, concerns and enablers in respect of the introduction of continuous monitoring devices were conducted with eight nurses and two doctors. The interviews were digitally recorded and transcribed. A general inductive approach [19] was used to analyse the interview data, whereby two researchers independently coded the data, discussed their coding and developed a coding schema. The schema was then used by one researcher to recode the data in QSR NVivo (NVivo 10). Results were reported to ward staff for validation.

Device trial and log books
Continuous monitoring devices were made available on each ward for staff to trial on themselves, in order to anticipate any problems patients may experience while wearing the device. Twenty-three nurses trialled the devices and provided written feedback in log books placed on each ward. The log book data were entered into a spreadsheet and independently analysed for common subject matter by two researchers.

Communication survey
A short paper-based survey was completed by 40 nurses. The survey contained a dichotomous (yes/no) question regarding whether current practices for identifying deteriorating patients could be improved; with an open-ended section requesting additional details. The survey also included five statements about interdisciplinary communication with 5-point Likert scales (Table 4). Quantitative survey data were analysed in SPSS (IBM SPSS Statistics 22) applying descriptive statistics. Open-ended responses were entered into a spreadsheet and independently analysed for common subject matter by two researchers.

Results
Knowledge survey
Nurses, particularly those from neurosurgery, were not confident about the accuracy of current equipment used to measure vital signs.

Table 2 Knowledge survey responses by study ward

<table>
<thead>
<tr>
<th>Statement</th>
<th>Respiratory</th>
<th>Neurosurgery</th>
<th>Respiratory</th>
<th>Neurosurgery</th>
<th>Respiratory</th>
<th>Neurosurgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taking manual observations is a time consuming task</td>
<td>4 (28.6%)</td>
<td>10 (52.6%)</td>
<td>0</td>
<td>2 (10.5%)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>You are confident that your automated observation machine is accurate</td>
<td>7 (36.8%)</td>
<td>6 (31.6%)</td>
<td>6 (21.4%)</td>
<td>3 (15.8%)</td>
<td>2 (10.5%)</td>
<td>0</td>
</tr>
<tr>
<td>You are uncertain of what to do if your machine is not calibrated or does not give proper readings</td>
<td>1 (5.3%)</td>
<td>6 (31.6%)</td>
<td>3 (15.8%)</td>
<td>7 (36.8%)</td>
<td>2 (10.5%)</td>
<td>0</td>
</tr>
<tr>
<td>You are confident about using tympanic thermometers correctly</td>
<td>6 (31.6%)</td>
<td>4 (21.1%)</td>
<td>3 (15.8%)</td>
<td>6 (31.6%)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>You are confident that your automated observation machine is accurate</td>
<td>4 (28.6%)</td>
<td>8 (47.4%)</td>
<td>3 (15.8%)</td>
<td>2 (10.5%)</td>
<td>3 (15.8%)</td>
<td>6 (31.6%)</td>
</tr>
<tr>
<td>The oxygen saturation (SpO2) probes in your ward don’t give accurate information</td>
<td>10 (52.6%)</td>
<td>5 (26.3%)</td>
<td>1 (5.3%)</td>
<td>2 (10.5%)</td>
<td>1 (5.3%)</td>
<td>0</td>
</tr>
<tr>
<td>You are confident activating the clinical review response system</td>
<td>8 (42.9%)</td>
<td>4 (21.1%)</td>
<td>3 (15.8%)</td>
<td>4 (21.3%)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>You are confident activating the rapid response system (medical emergency team)</td>
<td>9 (64.3%)</td>
<td>5 (35.7%)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sometimes you are reluctant to activate the rapid response system for your patients because you might be criticized if they are not that unwell</td>
<td>9 (64.3%)</td>
<td>5 (35.7%)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>You would activate the rapid response system for a patient you are worried about even if their vital signs are normal</td>
<td>7 (50.0%)</td>
<td>5 (31.6%)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*Respiratory ward total number of survey respondents = 14; Neurosurgery ward total number of survey respondents = 19.

Table 3 In-depth interview questions

1. How confident do you feel about identifying high-risk patients admitted to your ward who may require more frequent or ongoing monitoring of vital signs to prevent cardiac arrest and death?
2. In your ward, what is the basis for making a decision about the frequency of monitoring vital signs?
3. How easy would it be to fit an increased frequency of monitoring within nurses’ regular workloads?
4. What do you think are the benefits of a mobile device for continuous monitoring of vital signs?
5. Do you have any concerns about implementation of a mobile device that monitors vital signs all day and night?
6. What factors would motivate you to accept the introduction of the technology in your ward?
7. What barriers do you anticipate for the widespread introduction of this monitor if there was a plan to make it more widely available?
8. Do you think the introduction of this technology could affect the care of patients? Why?
9. If the hospital were to adopt this device, do you have any suggestions on how best to help staff with the transition from paper-based vital signs monitoring to a continuous electronic approach?
In-depth interviews

Four main themes emerged from the interviews: (i) current practices for identifying deteriorating patients; (ii) patient care and communication benefits of continuous monitoring; (iii) potential negative impacts of continuous monitoring on care practices; and (iv) training and support for successful implementation.

Current practices for identifying deteriorating patients

Nurses described confidence in their ability to identify patients at risk of deterioration using a range of levels, including 'medium', 'reasonably', 'fairly', 'pretty' and 'very'. Nurses confirmed that they use the vital signs threshold criteria mandated by State health department policy (the Between the Flags Program [20, 21]) to identify patient deterioration. Several stated they also rely on intuition or clinical judgement based on visual assessment of patients. If there is uncertainty about a patient, nurses said they perform double checks of vital signs, seek second opinions from other nurses or contact doctors.

I actually look at my patient and see whether or not they look like what the observations are showing and just use clinical judgement to see if they need to be more supervised. (Nurse3)

Both the doctors and nurses expressed concerns about the intermittent nature of the current system of vital signs monitoring. They indicated that a patient’s condition could markedly change between routine sets of observations and that these ‘gaps’ posed a potential to miss signs of deterioration.

I’ve had a patient who died on me … When I saw him he was reasonably ok and I thought—great, he’s stable, I’ll go and see somebody else. Then he crashed and burned in the next couple of hours and you couldn’t revive him. (Doctor1)

The doctors suggested that increased frequency of manual observation may not be feasible because of nursing work pressures. Nurses indicated that increased observations were conducted for patients when necessary, however, they disclosed it was onerous on their time and sometimes required nursing staff to be rearranged and patients reassigned.

Patient care and communication benefits of continuous monitoring

Continuous monitoring was considered to be a means of identifying trends that might otherwise be missed by intermittent monitoring. Both the doctors and nurses anticipated this could lead to earlier identification and response to patient deterioration, and potentially prevent deterioration to a stage requiring escalation to RRS intervention. Another perceived benefit was greater availability and accessibility to vital signs information, which nurses suggested would provide better evidence when communicating concerns for a patient to doctors and would support their decisions to escalate care.

Us nurses, we find it so difficult trying to get the doctors to understand what’s happening. … We’re like—this patient doesn’t look well; but they’re like—I’ll check her later. So at least when you show them—look, you need to come and see this patient now, this is what’s happening and that’s what the device is telling us. (Nurse8)

Some nurses perceived the devices would provide reassurance to patients, and their relatives, that the patient is being closely monitored. It was also suggested that visibility of information on the device might encourage patients to ask questions about their vital signs and, hence, be more engaged in their care. Alternatively, some nurses were concerned that visibility of information and alarms may cause anxiety amongst patients, leading to time spent reassuring them.

Table 4 Communications survey responses by study ward

<table>
<thead>
<tr>
<th>Statement</th>
<th>Respiratory</th>
<th>Neurosurgery</th>
<th>Respiratory</th>
<th>Neurosurgery</th>
<th>Respiratory</th>
<th>Neurosurgery</th>
<th>Respiratory</th>
<th>Neurosurgery</th>
<th>Respiratory</th>
<th>Neurosurgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>If doctors and nurses talked more frequently, we would be able to identify and respond to deteriorating patients earlier</td>
<td>Strongly agree</td>
<td>13 (59.1%)</td>
<td>5 (29.4%)</td>
<td>13 (59.1%)</td>
<td>6 (35.5%)</td>
<td>6 (27.3%)</td>
<td>6 (27.3%)</td>
<td>2 (11.8%)</td>
<td>2 (11.8%)</td>
<td></td>
</tr>
<tr>
<td>Patient care would be improved if doctors and nurses had more opportunities to talk about the patient</td>
<td>Agree</td>
<td>8 (36.4%)</td>
<td>11 (64.7%)</td>
<td>8 (36.4%)</td>
<td>10 (58.8%)</td>
<td>4 (23.5%)</td>
<td>8 (47.1%)</td>
<td>8 (47.1%)</td>
<td>8 (47.1%)</td>
<td></td>
</tr>
<tr>
<td>Doctors and nurses work together to decide what medical information (e.g. procedure, medication or condition) should be given to patients</td>
<td>Uncertain</td>
<td>0</td>
<td>1 (5.9%)</td>
<td>0</td>
<td>1 (5.9%)</td>
<td>4 (23.5%)</td>
<td>8 (47.1%)</td>
<td>8 (47.1%)</td>
<td>8 (47.1%)</td>
<td></td>
</tr>
<tr>
<td>The doctors keep me informed about the medical information/advice they have given to my patients</td>
<td>Disagree</td>
<td>1 (4.5%)</td>
<td>0</td>
<td>1 (4.5%)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>It is easy for me to talk to the doctors about my patients</td>
<td>Strongly disagree</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
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</tbody>
</table>

*Respiratory ward total number of survey respondents = 23; Neurosurgery ward total number of survey respondents = 17; not all respondents answered all questions.
Potential negative impacts of continuous monitoring on care practices

Both the doctors and nurses expressed concern about the potential for over-reliance on the continuous monitoring remote viewing displays resulting in decreased bedside interactions and, subsequently, reduced physical and visual assessment of patients. One nurse was apprehensive that the device would replace a quintessential nursing responsibility, while others felt that not having to measure vital signs would allow them more time to focus on other care needs.

My initial concern was that nurses may not have that one-on-one interaction with the patients. That may reduce because they will rely on the device. (Nurse 3)

I’m hoping it will give staff more time to have that patient care and that patient contact that everyone complains they don’t get enough of. (Nurse 4)

Nurses were also concerned that continuous monitoring would be less flexible with regards to adjusting for clinical judgement and worried about their decisions to override alarms being scrutinized. One nurse provided the example of SpO2 levels falling below indicated thresholds when patients get up to use the bathroom, which are known to return to acceptable levels once the patient rests. In such cases, nurses would not generally escalate. Likewise, the doctors were concerned that continuous monitoring may result in more clinical reviews and RRS calls that may be inappropriate. They suggested this could lead to doctors becoming overburdened and ultimately, if many calls were unwarranted, could result in doctors becoming desensitized to calls. One of the doctors also suggested that alert fatigue may be an issue for nurses if the devices generated alarms too frequently.

Training and support for successful implementation

Training was highlighted as a key requirement for the introduction of continuous monitoring devices. Nurses wanted the opportunity to interact with devices prior to implementation and felt that success of implementation hinged on the provision of education about all aspects of the devices, including placement on patients; device operation; interpretation of data; and actions required in response to data. They also indicated that access to technical support or ward champions who could assist with troubleshooting issues was important.

Device trial

Nurses who trialled the continuous monitoring devices provided a total of 53 feedback comments (median 2 comments per nurse, range 1–5). Nurses reported wearing the device for durations ranging between 15 minutes to several hours.

The most frequently mentioned issue related to the device being bulky/heavy and uncomfortable to wear (n = 17 comments). Nurses found it difficult to perform activities while wearing the device (n = 7) such as eating, washing hands, or typing, and complained about the device’s leads getting in the way or being constrictive (n = 5). They also reported technical problems (n = 8), such as responsiveness of the screen to input, and questioned the robustness and ease of cleaning the device (n = 3). Nurses raised concerns about devices causing patients anxiety or possibly injury, such as pressure sores (n = 5). Some commented they were excited about the devices and their potential to assist in the early detection of deterioration (n = 4). Others expressed indifference (n = 3), while one nurse expressed concern that the devices would replace nurses (n = 1).

Communication survey

The demographic characteristics of the nurses participating in the communication survey are presented in Table 5. Most nurses (n = 29 of 40; 72.5%) reported that the way deteriorating patients are currently identified could be improved and 21 (52.5%) provided comments on how this could be achieved. Comments regarding communication (n = 9 comments) were frequent, such as communication of clear plans of care and criteria for escalating patients; improved bedside handover compliance; and listening to nursing staff when they voice concerns regarding deteriorating patients. Other comments included increasing the frequency of monitoring (n = 6); locating high-risk patients close to the nurses’ station for easier visibility (n = 3); and maintaining low nurse-to-patient ratios or rostering more senior staff (n = 3).

Almost all nurses agreed or strongly agreed (n = 37 of 39; 94.9%) that if communication between doctors and nurses was more frequent, nurses would be able to identify and respond to deteriorating patients earlier and that patient care would be improved. A large number of nurses indicated that doctors and nurses work together only sometimes to decide what medical information should be communicated to patients (n = 14; 35.9%) and that doctors only sometimes kept nurses informed about the advice they had given patients (n = 24; 61.5%). All nurses indicated that they found it easy to talk to doctors about patients at least sometimes.

Discussion

In this study, clinical staff perceived there were opportunities to improve current vital signs monitoring practices. Nurses expressed concerns about current monitoring frequency and equipment, and indicated that a patient’s condition could destabilize and go unnoticed between routine sets of observations. They also felt that interdisciplinary communication, in relation to patient deterioration and care, could be improved. However, there were mixed responses regarding the prospect of continuous monitoring technology on general wards. On the one hand, it was seen as safer for patients by

<table>
<thead>
<tr>
<th>Table 5 Demographic data of nurses completing the communications survey</th>
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<tbody>
<tr>
<td>Demographic</td>
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<tr>
<td>---</td>
</tr>
<tr>
<td>Gender</td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td>Age (years)</td>
</tr>
<tr>
<td>18–29</td>
</tr>
<tr>
<td>30–44</td>
</tr>
<tr>
<td>45 and above</td>
</tr>
<tr>
<td>Qualification</td>
</tr>
<tr>
<td>Enrolled nurse</td>
</tr>
<tr>
<td>Registered nurse</td>
</tr>
<tr>
<td>Nursing experience (years)</td>
</tr>
<tr>
<td>1–3</td>
</tr>
<tr>
<td>3–5</td>
</tr>
<tr>
<td>5 or more</td>
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</tbody>
</table>

*Only 21 respiratory nurses provided their age and only 22 provided their years of nursing experience.
allowing trends to be identified and responded to earlier. This finding reflects evidence from two recent studies that assessed the impact of continuous monitoring in general wards and found early identification of deterioration, increased rapid response activation and a decreased need for patient rescue to be benefits of continuous monitoring [22, 23]. However, a systematic review of literature published between 1998 and 2010, as well as a quasi-experimental study published in 2014, found that these benefits have also been associated with intermittent monitoring strategies, such as early warning scoring systems [24, 25]. The continuous monitoring devices were also considered to be a means to encourage patient engagement in their care, which could facilitate the patient to be observant of and involved in their own safety [26].

On the other hand, there was apprehension about potentially negative impacts of continuous monitoring, particularly on nurse-patient interactions, inflexibility of using clinical judgement, patient anxiety leading to need for reassurance and that the technology would replace an essential nursing responsibility. As a previous qualitative study of clinicians’ and managers’ views of information technology introduction identified, concerns regarding disruption to workflow and work processes predominate over other issues [27].

Conflicting views were also found on whether continuous monitoring would free up time to spend with patients, allowing nurses to focus on other patient care needs, or whether released time might be time spent away from patients. This is a particularly important issue, as time spent away from patients reduces opportunities for visual assessment of deterioration. Nurses indicated that they do not solely use vital signs data to monitor patients. When detecting deterioration nurses also rely on their intuition and use sensory assessment to identify subtle changes in their patients, such as changes in skin colour, level of agitation or the clamminess of skin [28, 29]; but detection is reliant on nurses interacting with patients. To mediate potential decreases in bedside interactions, the capability of the devices to complement nurses’ clinical judgement, strengthening the nurses’ role as the one overseeing the technology, is an important message to be conveyed to nurses during the implementation of continuous monitoring devices. Emphasizing such a message may help alleviate nurses’ concerns about being replaced by technology [30] and, thus, would be important to include as part of training, which staff identified as critical to facilitating adoption and acceptance of technology [31].

Most nurses felt reasonably confident in their ability to identify patients at risk of deterioration. They emphasized the need to recheck abnormal readings; adjust criteria for escalation; and increase monitoring frequency for patients whose condition was deteriorating. The neurosurgery nurses expressed less confidence than the respiratory nurses in the accuracy of their vital signs equipment and were more uncertain about the actions to take if they felt equipment readings were inaccurate. A reason for this may be differences in how patients deteriorate on the two wards (with respiratory patients generally exhibiting a slower decline compared to neurosurgery patients) and differences in nursing experience, which has been identified as a predictor of attitudes towards vital sign monitoring [32]. Nonetheless, almost all nurses expressed confidence in escalating care when they were concerned, even for patients with vital signs within normal thresholds. However, the nurses admitted at sometimes being reluctant to escalate care because of possible criticism by doctors. A previous survey of nurses’ attitudes towards RRS similarly found that ~13% felt uncomfortable placing a MET call [33]. Nurses in the present study suggested that a benefit of continuous monitoring was the provision of better evidence when communicating concerns about patients to doctors. This would also address previous suggestions that some reluctance in escalating care is due to a disconnect between the social language generally used by nurses and the technical language often used by doctors [34, 35]. The findings also highlight the need for ongoing education, particularly for less experienced nurses, to allow them to develop their vital signs knowledge and confidence in their clinical reasoning skills [32].

The issues of potential alert fatigue or an increase in inappropriate escalations of care were raised by one of the doctors. These issues are important to monitor with the implementation of continuous monitoring devices, as alarms or escalations of care that are often false-positive can compromise patient safety by causing delays in response times [36]. In one setting, where continuous monitoring devices were implemented, the average alarm rate was 10.8 per patient per day, which the majority of nurses perceived to be acceptable (n = 22 of 24 nurses) [37]. However, the appropriateness of continuous monitoring alarms and nurses responses is an area requiring further study.

Limitations
Our study had several limitations. We received modest participation rates for the individual research activities (up to 49%) and participants were predominantly nurses, with only two doctors participating, which limits the ability to infer the perspectives of doctors. Overall, however, of the cohort of 81 nurses on the two study wards, almost all participated in at least one of our research activities. Across the four research activities we had a total sample of 106 participants, thus our use of multi-methods added strength to our study design [38, 39]. We also validated the findings of each research activity through feedback presentations to ward staff, including both those that had and had not participated in the research activity, to strengthen the credibility and trustworthiness of our study findings [40]. Our study was conducted in two wards of one hospital and, hence, the findings may not be generalizable to other settings. Nonetheless, this study identifies important information to inform technology implementations and these transferable lessons should be considered by those seeking to adopt continuous monitoring technology.

Conclusions
Technologies are frequently introduced into health care settings without sufficient prior consultation of end users. Yet, end-users’ attitudes can influence the acceptability and integration of technology into clinical work practices [41]. This study examined clinical staff views about current intermittent measurement of vital signs and about implementing continuous monitoring devices on general wards. The attitudes and beliefs of staff were a combination of expected benefits for improved patient care, and concerns about integration of the devices into existing practices. While continuous monitoring devices were seen as a positive tool to support the early identification of deterioration, drawbacks were also identified, such as the potential for reduced patient contact. Effective training and improved interdisciplinary communication were identified as key requisites for successful implementation. These drawbacks and requisites highlight key areas that require close consideration and surveillance following the implementation of these devices, and present an area for further study with a larger sample of clinicians.
Acknowledgements

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