

Factors Influencing Use of Continuous Physiologic Monitors for Hospitalized Pediatric Patients

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ABSTRACT

OBJECTIVES: Continuous physiologic monitors (CPMs) generate frequent alarms and are used for up to 50% of children who are hospitalized outside of the ICU. Our objective was to assess factors that influence the decision to use CPMs.

METHODS: In this qualitative study, we used group-level assessment, a structured method designed to engage diverse stakeholder groups. We recruited clinicians and other staff who work on a 48-bed hospital medicine unit at a freestanding children's hospital. We developed a list of open-ended prompts used to address CPM use on inpatient units. Demographic data were collected from each participant. We conducted 6 sessions to permit maximum participation among all groups, and themes from all sessions were merged and distilled.

RESULTS: Participants ($n = 78$) included nurses (37%), attending physicians (17%), pediatric residents (32%), and unit staff (eg, unit coordinator; 14%). Participants identified several themes. First, there are patient factors (eg, complexity and instability) for which CPMs are useful. Second, participants perceived that alarms have negative effects on families (eg, anxiety and sleep deprivation). Third, CPMs are often used as surrogates for clinical assessments. Fourth, CPM alarms cause anxiety and fatigue for frontline staff. Fifth, the decision to use CPMs should be, but is not often, a team decision. Sixth, and finally, there are issues related to the monitor system's setup that reduces its utility.

CONCLUSIONS: Hospital medicine staff identified patient-, staff-, and system-level factors relevant to CPM use for children who were hospitalized. These data will inform the development of system-level interventions to improve CPM use and address high alarm rates.



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Drs Schondelmeyer and Vaughn conceptualized and designed the study, analyzed and interpreted the qualitative data, drafted the initial manuscript, and reviewed and revised the manuscript; Dr Jenkins contributed to the interpretation of the qualitative data, drafted the initial manuscript, and reviewed and revised the manuscript; Ms Loechtenfeldt, Ms Timmons, Mrs Pope-Smyth, and Ms Allison contributed to the design of the study, coordinated the collection of data, helped analyze the data, and reviewed and revised the manuscript; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Alarms from continuous physiologic monitors (CPMs) (eg, cardiorespiratory and pulse oximetry monitors) occur in overwhelming numbers in children's hospitals.^{1,2} CPMs are intended to identify patients who are deteriorating, but their efficacy is limited by alarm fatigue,³ and there is no evidence that they improve patient outcomes.⁴ Alarm fatigue, defined as desensitization due to high rates of false or clinically inconsequential alarms, has been linked to multiple deaths and morbidity among patients who are hospitalized.⁵⁻⁸ Alarm fatigue is of particular concern in the children's hospital setting, where 99% of alarms in general pediatric units are not clinically actionable.⁹ More than 10 000 alarms can occur on a single pediatric unit in 1 week, and >150 alarms for a patient who is monitored can occur in 24 hours.^{1,2} Clinicians faced with high alarm rates may delay or not respond to potentially critical patient events.

In national guidelines, the utility of CPMs for specific patient populations has been questioned and the potential harm of CPMs has been highlighted, including overdiagnosis and admission of patients who might be safely observed as outpatients.^{10,11} Evidence also reveals that clinicians may overvalue the benefit that continuous monitors confer for the safety of patients. Studies in which authors assessed the utility of continuous telemetry for adult patients who were hospitalized revealed that it contributed to an important change in clinical care for a minority of patients.^{12,13} A recent study also revealed that in-person assessments may be superior to electronic measurements of respiratory rate for the identification of patients at risk for deterioration.¹⁴ However, despite these concerns, clinicians use CPMs frequently; a study of 5 children's hospitals revealed that CPMs were used for up to 50% of children outside the ICU.²

There is currently no guideline that addresses when CPMs should be used for most children who are hospitalized, and studies of the rationale for widespread CPM use are lacking. Understanding which factors drive the use of CPMs will be critical to the development of interventions used to

target reductions in alarms and monitor use. Knowledge directly from clinicians about the value in using CPMs and about what drives them to use (or not use) these devices will be important to reduce monitor use in patients when it is less likely to be helpful. Our objective was to assess patient-, clinician-, and system-level factors that influence CPM use and their impact on the clinical environment.

METHODS

Study Setting

This qualitative study was conducted at a quaternary care center with >600 registered beds and 1.2 million encounters a year. Patients who are hospitalized are predominantly admitted to a 48-bed unit staffed by pediatric nurses. Pediatric resident trainees supervised by hospitalist physicians provide direct patient care. Each patient room in the unit is equipped with a bedside monitor with the ability to continuously measure heart rate, respiratory rate, and pulse oximetry values. There are preset thresholds that generate alarms for out-of-parameter values. In addition to audible alarms in the patient room and at the front desk, indicator lights above the door outside of each patient room provide a visual signal.

This study was approved by our hospital institutional review board.

Study Method

We employed a structured participatory research method called group-level assessment (GLA).^{15,16} GLA is designed to promote full engagement with diverse groups of participants, including those in which there may be a perceived hierarchy, and encourage the expression of minority opinions. Participants in our study included staff in various positions (nurse, unit coordinator, patient assistant, nurse practitioner, physician, and resident trainee) within the hospital; thus, GLA conferred specific advantages over other qualitative methods, such as focus groups, in which perceived hierarchy may more readily inhibit full participation.¹⁵

The GLA sessions used an established 7-step process (Fig 1) in which data were generated through a collaborative,

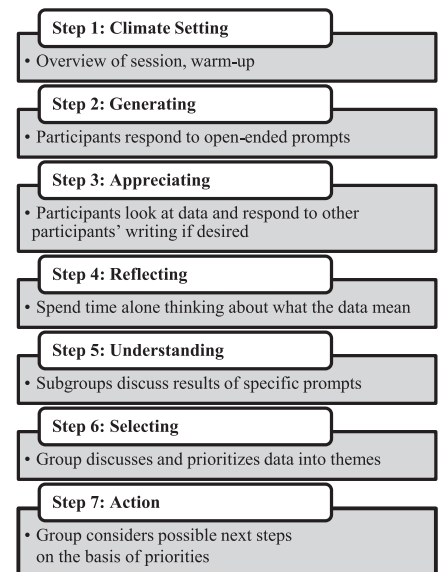


FIGURE 1 The GLA process.

structured approach that employed a series of open-ended prompts (eg, "Continuous monitors are most/least helpful for..."; a complete list is in Supplemental Table 3). Sessions were facilitated by an experienced moderator and qualitative methods expert (L.M.V).

Participant Selection and Study Procedure

Participants were recruited from a 48-bed hospital medicine unit where CPMs are routinely used. This unit cares for children with acute (eg, asthma and dehydration due to gastroenteritis) and chronic and complex medical needs (eg, neurologic impairment and tracheostomy dependency) and has been identified in previous work to have a high proportion of patients who are monitored and high alarm rates.^{1,2}

Participants were recruited by using e-mail and paper advertisements posted throughout the unit and in work areas. Unit-based participants, including nurses, respiratory therapists, unit coordinators, and patient care assistants, were eligible to participate if they spent most of their clinical time working on the hospital medicine unit. Hospitalist physicians and nurse practitioners as well as resident trainees, if they had completed at least a

1-month hospital medicine rotation, were also eligible to participate.

During the session, participants were asked to complete a demographic form that included information such as job title and years in practice (or for trainees, year in training). Three GLA sessions that included physicians, resident trainees, nurses, and other unit staff members were conducted to completion. Because of challenges related to conflicting shift schedules, the longer GLA sessions were followed by several shortened GLA sessions, including (1) a trainee session conducted during an existing meeting time and (2) 2 on-unit sessions in which nursing and unit-based staff were targeted during day and overnight shifts. This was done to ensure the collection of all relevant themes and adequate participation from all stakeholder groups. Participants in all sessions were guided through the initial GLA steps, including responding to prompts and reflecting on the data. Detailed notes were taken by research team members during all sessions to help contextualize data for overall analysis and to capture illustrative quotes.

Analysis

Demographic data were summarized by using means and SDs. Themes were merged across all sessions by the study group, which included a nurse (B.A.), 2 physicians (A.C.S. and A.M.J.), a qualitative methods expert (L.M.V.), and research staff (K.M.T., A.M.L., and S.T.P.S.), who had been present in-person for all sessions. The data from the first 3 sessions, which were conducted to completion of the GLA process, were analyzed first. Data from the shorter GLA sessions were then reviewed iteratively because each session was conducted to identify any additional themes that were not discovered in the initial sessions and to assist in prioritizing themes on the basis of the participants (ie, identifying themes that were most salient for nurses versus resident trainees).

RESULTS

Participants

A total of 78 individuals participated in our study's 6 GLA sessions. Participants included

nurses (37%), attending physicians (17%), pediatric resident trainees (32%), and unit staff (eg, unit coordinator; 14%). There was a broad distribution in years of experience, with nurses being the most experienced group (Table 1).

Themes

Six primary themes were distilled from the GLA sessions regarding influences on CPM use and impact of CPM use on the clinical environment. Details are discussed below, with brief explanations summarized in Table 2.

CPM as a Surrogate for Clinical Assessments

Participants perceived that monitors were consistently used as surrogates for in-person assessment, with concerns that inexperience lead to overvaluing what monitors add to clinical care. The sentiment "I love monitors, I hate alarms" from 1 resident participant revealed an underestimation of harm from alarm fatigue. Clinical assessment was perceived as the more appropriate tool for evaluating a patient's status in many cases. Participants noted that automatic electronic medical record ordering, overestimation of efficacy of monitors to prevent adverse events, and ineffective communication among providers contributed to broad CPM use.

CPM Alarms Cause Anxiety and Fatigue for Frontline Staff

Nursing staff, unit coordinators, and patient care assistants alike noted high numbers of alarms, of which many were perceived to not be clinically meaningful. Response to alarms was also felt to be dependent on experience; less experienced staff may

become more stressed, and more experienced staff may tend to ignore alarms. One physician noted, "Monitors are the boy who cried wolf." One unit coordinator stated, "I either respond to everyone, or I respond to no one," when describing her experience sitting at the unit front desk, which houses a centralized CPM screen and alarms for all patients on the unit. Without the clinical knowledge to triage, she perceived that she had to notify nurses for all alarms or none at all.

Patient-Specific Factors for Which CPMs Are Useful

Participants identified broad patient population categories that helped determine the usefulness of CPMs. Participants uniformly perceived that patient-specific factors, such as whether a "patient is actually sick," should drive the decision to use CPMs. Other identified populations for whom CPMs were felt to be helpful included patients who were unstable, patients with complex needs (eg, tracheostomy), and patients with no family present. Most unit staff had a desire for an easy way to capture vital signs for a patient who was sleeping without moving or disturbing the patient. Conversely, CPMs were considered unhelpful in active patients who pulled their leads off. Usefulness was also considered dependent on whether parameters were set to levels that required a response. Significant uncertainty existed in all groups about when monitors were clearly useful. Hospital-based policy was felt to be unclear or felt to not always make sense on the basis of the patient. One participant noted, "We don't know what we know, and we don't know what we don't

TABLE 1 Participant Demographics

| | Participant Characteristics, <i>n</i> (%) | Years of Experience, Mean (SD) |
|---------------------|---|--------------------------------|
| Female sex | 64 (82) | — |
| Job title | | |
| Attending physician | 13 (16.7) | 5.5 (3.2) |
| Nurse | 29 (37.2) | 11.3 (8.2) |
| Resident | 25 (32.1) | 1.1 (0.7) |
| Unit staff | 11 (14.1) | 13 (11.7) |

—, not applicable.

TABLE 2 Themes With Brief Explanations Based on Participant-Generated Data

CPMs as surrogates for clinical assessments

- Nurses and physicians use monitors as surrogates for clinical assessment.
- Reliance on CPMs for assessments is associated with less experienced staff members.
- Less experienced staff overvalue monitors and underappreciate harm from alarm fatigue.

CPM alarms cause anxiety and fatigue for frontline staff

- Alarm rates are high, and most alarms are not clinically meaningful.
- High alarm rates cause reactions ranging from stress to ignoring alarms.
- Less experienced staff are more likely to become stressed and ignore alarms.

Patient-specific factors for which CPMs are useful

- Monitors are helpful for patients who are unstable or complex, for patients with no family present, and for assessing patients who are sleeping; they are unhelpful in active patients who pull their leads off.
- CPM utility depends on whether alarm parameters were set to levels that require a response.
- There is uncertainty about when monitors are effective, and hospital policy is unclear and does not always make sense on the basis of the patient.

CPM alarms have negative effects on families

- Alarms negatively impact families.
- Family reactions to alarms include lost sleep, anxiety, concerns about why hospital staff do not always respond to alarms, and misperception about why monitors are used.
- Reactions to monitors and alarms differ from family to family.

Setup of CPM system

- Nurses do not hear alarms for other patients who are monitored when they are in a patient's room.
- Alarms are missed despite alarms being audible throughout the unit.
- The presence of alarm sounds in the room is detrimental for patients and families.

The decision to use CPMs

- Clinicians attribute the desire for CPMs to other medical team members.
- CPMs are reassuring for nurses and physicians and are often used without physician order.
- Factors contributing to CPM use include families' desire for monitoring and hospital policy.
- The decision to use CPMs should include the entire medical team and the patient and family.

problem that became a day shift problem.” Nurses reported difficulty in getting residents to discontinue monitors; during the night shift specifically, the decision was often deferred to the day team. All participants felt that CPM use should be a group decision with the entire medical team and should possibly include the family. Moreover, continued use of CPMs was frequently attributed by participants to other members of the care team. For example, nurses perceived that resident physicians often wanted to keep monitors; likewise, resident physicians perceived that nurses often placed patients on CPMs without an order. Participants identified the following reasons for why CPM use continued through hospitalization: (1) monitors are desired by families, (2) hospital policy requires their use, (3) CPMs provide reassurance for nurses and physicians, and (4) monitors are often used without an order. The involvement of all stakeholders was identified as an essential component of determining CPM use. Furthermore, when considering when to turn off CPMs, multiple participants identified “practicing out of fear” and being “scared of the ‘what if’” as barriers to discontinuation.

Overall, participants expressed a series of themes that reflected how they weighed the benefits and harms of CPMs in their daily practice given the limitations of the current monitoring system. Using these concepts, we created a theoretical model to understand the elements that factor into how staff view CPM use (Fig 2). The model takes the form of a scale, with the fulcrum representing the various groups with a stake in the decision. The model reveals the basis of CPM decision-making that occurs between patients, families, nurses, and physicians, revealing a shifting balance of what participants perceived to encourage CPM use (listed to the right) and what they perceived as CPM deterrents (listed to the left).

DISCUSSION

In our study, we provide insight into the overall purpose and utility of CPMs from the perspective of frontline providers. As illustrated in our theoretical model (Fig 2),

know,” illustrating that there is ambiguity about the utility of CPMs in local guidelines and in the medical literature.

CPM Alarms Have Negative Effects on Families

Concerns were consistently raised by all participants about the impact of alarms on families. One nurse stated, “It’s a vicious cycle for patients and families without sleep.” Although health care staff perceived that responses varied by families, sleep deprivation, anxiety, concerns about why staff were not responding to alarms, and misperceptions about why monitors were being used were all referenced as potential family reactions. One nurse noted, “Some parents think there are people constantly watching monitors, so [they] wonder what’s going on when no one comes in.”

Setup of CPM System

Nurses and unit staff raised concern about the current positioning of the monitors. At the time of this work, the audible alarms could be heard in patients’ rooms and at the front desk. This resulted in alarms “beeping everywhere” but then not being audible down the hallway or in other patient rooms. Nurses reported that this resulted in them commonly being unable to hear the alarms. One nurse noted, “[Nurses] are not paged who is alarming, which leads to alarms possibly being missed.” Additionally, all participants perceived that patients and families did not benefit from the current setup of alarms in patient rooms.

The Decision to Use CPMs

Desire for CPMs was often attributed to another party, and as such, as 1 nurse reflected, “monitors are a night shift

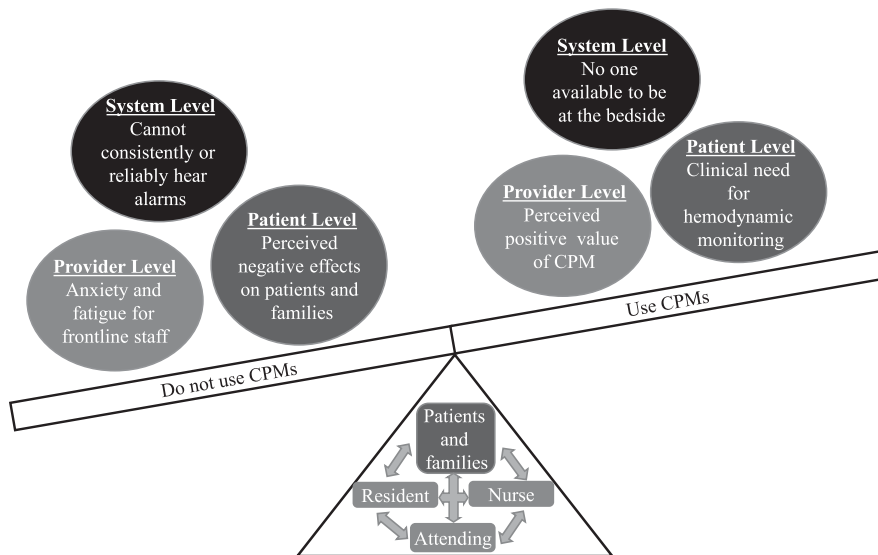


FIGURE 2 Theoretical model.

several patient, staff, and system-level factors were described by participants as affecting the decision to use or discontinue CPMs. Whereas most participants felt that CPMs were often surrogates for clinical assessment, others reported that purposes of CPM use were highly participant dependent. Nurses specifically felt that CPMs were useful when caregivers were not present at the bedside, irrespective of a patient's clinical condition, but also perceived that families were frustrated by any delays in response to alarms. Interestingly, participants attributed the drivers of CPM use to other care team members.

Having someone at the bedside of a child who is hospitalized is important for many reasons, including recognizing clinical changes in patients who often cannot advocate for themselves. Although providers perceived that CPMs were helpful when a child did not have a caregiver present, CPM systems were not originally designed for this type of surveillance.^{17,18} Evidence that they improve outcomes, even in patients who are critically ill, is lacking.⁴ Although cited by staff as a reason for wanting CPMs, lack of a caregiver at the bedside does not automatically confer benefit of CPMs and may contribute to additional uncertainty by all care team members of the CPM purpose. Additionally, using CPMs for patients who

are clinically stable solely because there is no family in the room may account for a higher proportion of artifactual alarms due to movement; thus use for this subset of patients is particularly worrisome. This may represent a few issues for staff: an educational gap about the poor specificity of CPMs in a setting in which care teams are trying to detect rare events, an overvaluing of the impact of CPMs on patient safety, and/or an attempt to use CPMs to solve another problem (eg, inadequate resources to allow for continuous child supervision). Dissonance clearly exists between implicitly perceived benefits of using CPMs to monitor an child who is unsupervised and the explicitly stated indications for CPM usage.

It is problematic that staff report using CPMs as surrogates for in-person assessment. Literature in adult hospitals has revealed that clinicians may overvalue the degree to which continuous monitoring adds to patient safety^{12,13} and that clinicians have poor knowledge of how monitoring systems work.^{19–22} Our findings from the pediatric hospital setting complement this work because participants frequently cited overestimation of monitor efficacy to prevent adverse events and commented on the practice of using CPMs in place of in-person assessments. Nurses, despite reporting that they rely on CPMs for patient assessment, specifically noted that if they

are not in the room or by the workstation, they do not hear alarms. Interestingly, no participants commented on the presence of alarm-indicator lights above the patient room door.

Alarm fatigue is a challenging problem across health care settings.²³ Previous work revealed that routine alarm rates on general hospital medicine units would necessitate that a nurse with 4 patients who are monitored respond to an alarm every 4 minutes.¹ One study revealed a dose-response effect because progressively higher numbers of nonactionable alarms correlated to increasing nurse response times.⁹ Taken in the context of alarm fatigue, our study's findings regarding providers attributing the choice of using CPMs to others may reflect some degree of role confusion and conflict and, as such, could function to promote mistrust among the care team. On the basis of our data, several improvements could be made to the monitoring process: (1) having inclusive discussions with the patient's care team and family members about using CPMs, (2) targeting monitor use for patients with physiologic instability or unclear illness trajectories, and (3) altering the CPM system setup, such as delivering alarms directly to the nurse. Future research directions to optimize CPM use should include the evaluation of interventions used to address care team knowledge gaps, role clarification, functioning, and communication about the monitoring system. Although studies of the efficacy of monitoring are difficult because of the rare nature of most negative outcomes (eg, code events), existing evidence could be combined with expert opinion to better guide clinician decisions about appropriate CPM use.

This study has limited generalizability because health care systems may have varying reasons to use CPMs that may be dependent on patient populations, monitoring infrastructures, or staffing ratios. Additionally, our institution is a teaching hospital, with residents providing direct patient care; this adds complexity to decisions on CPM use. Despite the limitations, there is evidence that alarm

rates are high across children's hospitals²; therefore, these themes may resonate despite contextual differences. Variability in monitoring practices that has been described across pediatric hospitals² may result from similar perceptions of value of CPMs and of care team members' roles in driving discontinuation. Finally, participants identified patients and families as stakeholders, hypothesizing that patients and families may view both CPMs and alarms as burdensome during hospitalization. Further work will be necessary to understand the patient and family perspective in this process.

Although the GLA process is designed to encourage expression of minority opinions and allow trust-building between different stakeholders, the presence of multiple types of staff may have biased responses. However, similar themes arose from sessions with predominantly 1 stakeholder type (eg, mostly nurse participants), representing a smaller risk of bias. Finally, as with studies that rely on participants to recount their behavior, there is a risk that responses may have been influenced by availability heuristics²⁴ or by staff reporting what they perceived to be a socially desirable response that may not necessarily reflect what they do in practice.

CONCLUSIONS

A group of hospital staff identified several patient-, staff-, and system-level factors that are relevant to CPM use for children who are hospitalized. Further work to understand the patient and family perspective will be important. These data will inform the local development of system-level interventions and guidelines to improve CPM use and address high alarm rates.

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