
What evidence exists that describes the impact of continuous monitoring on patient safety on non-critical pediatric inpatient units?

This report aims to summarize the best available evidence around the safety and implications of continuous monitoring on non-critical pediatric inpatient units. This information is to support a new protocol being introduced via the Clinical Practice Review Committee at the MUHC.

Key Messages:

- Continuous monitoring, where physiological patient data is being constantly recorded and reported, is standard in critical care areas to facilitate a quick response to potential physiological deterioration.
- Continuous monitoring is considered in non-critical inpatient wards over intermittent monitoring to improve detection of physiological deterioration and to reduce the incidence critical events and admission to intensive care units.
- Studies investigating the effectiveness of continuous monitoring on patient and organizational outcomes in non-critical areas are limited in quantity and quality, especially in the pediatric population. The best available evidence suggests that:
 - Intermittent physiological monitoring is safe in children hospitalized for an acute bronchiolitis who show clinical improvement.
 - There is insufficient evidence to recommend continuous monitoring to improve the management of critical events, including ICU admission, outreach team involvement, cardiopulmonary instability and death in adult patients hospitalized in general medical/surgical wards.
 - Continuous monitoring is advocated for any hospitalized patient who is administered opioids.
- There are multiple components that influence the outcomes of a monitoring strategy. This includes sensors that are highly sensitive with positive predictive value for the patient population; patient tolerance to the sensors; and critical thinking skills of practitioners responding to and interpreting alarms.
- The condition known as “alarm fatigue” was identified in the literature as a major challenge to patient safety in response to continuous monitoring technology in general and critical care areas. Recommendations to combat this condition were made based on limited evidence and include:
 - Optimizing alarm delay and threshold settings to the context, patient population and individual patient.
 - The development and implementation of protocols and procedures to address issues related to alarms and response to alarms.
 - Ongoing training of staff using physiological monitors.

Who is this summary for?

This summary was requested by Stephanie Lepage, NPDE & Chantal Souigny, ADON Child and Adolescent Mission, MUHC.

Information about this summary:

This report covers a broad collection of literature and evidence sources with a search emphasis on systematic reviews.

This summary includes:

Key findings from a broad collection of recently published literature (2009-2015) and evidence sources.

This summary does not include:

Recommendations, additional information, or detailed description of the interventions in the studies.

1. Background:

Continuous physiological monitoring is a strategy regularly used in critical care areas to rapidly detect physiological deterioration in individual patients in order to minimize the delay to intervention [1]. In non-critical areas, such as medical and surgical wards, monitoring is usually intermittent and occurs as part of routine spot checks measuring physiological parameters such as heart rate, respiratory rates, oxygen saturation and temperature [2]. Rapid deteriorations on non-critical inpatient units leading to morbidity, mortality and strain on the hospital system occur due to the higher acuity of patients and the decrease of clinical resources causing some to implement continuous monitoring in these areas. In the pediatric population, further concern arises since the ability for patients to communicate is highly dependent on their developmental stage. However, the evidence is not clear as to whether continuous monitoring is effective in non-critical areas.

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The effectiveness of monitoring practices is dependent on multiple variables [3]. Outcomes such as mitigation of critical events, admission to the intensive care unit, involvement of outreach teams such as rapid response teams, serious morbidity and death are the result of multiple actions or inactions by healthcare workers and the system. As well, alarm fatigue, which is the delayed or inadequate response to alarms due to healthcare provider desensitization, complicates the interventions needed for continuous monitoring to be implemented accurately. These factors contribute to a complex phenomenon for research study [4].

This rapid review will present summaries of the best available evidence with regards to continuous physiological monitoring on non-critical inpatient units. A detailed search strategy was developed by an experienced librarian (specific search terms are available upon request). Sources included Medline via OvidSP, Pubmed via NLM and CINAHL Complete via EbscoHost. Search concepts included Subject Headings and text words. The search date was January 2005 to January 8, 2016. Duplicates and out of scope articles were discarded by the librarian. In addition, the EIDM-Advisor reviewed the cited references of the included articles. The analysis of studies, including appraisal and summary, and the final report were prepared by the EIDM-A and reviewed by the librarian and Chair of the Clinical Practice Review Committee of the MUHC.

The studies included in this rapid review were conducted on non-critical inpatient units. Non-critical was defined as a medical, surgical, hematological/oncological or other inpatient ward that is not critical care (intensive care, pediatric intensive care or neonatal intensive care). In addition, a Cochrane systematic review of stroke unit monitoring was also excluded after consultation with the user (SL). Studies involving pediatric and adult population were included due to the paucity in the pediatric literature. Articles that included alarm fatigue in non-critical inpatient wards were included. Articles discussing or evaluating early warning scoring systems or tools, or studies that evaluated specific monitoring equipment were excluded, although they may be relevant for additional information.

One systematic review was found evaluating the effectiveness of continuous versus intermittent monitoring on the general adult inpatient ward. Studies that were reviewed by the systematic review were not summarized again. One RCT was found in the pediatric population but with a small sample size. The other studies are of moderate

quality and the overall level of evidence is low. A table of all the articles found and summarized is available upon

Levels of Evidence (adapted from OHRI KTA Evidence Summary document)

Each piece of evidence presented in this summary is assigned a level.

This assignment is based on the evidence being presented and not on the claim made by the authors.

⚙️ **Platinum:** Systematic reviews and meta-analysis

✳️ **Gold:** Randomized controlled trials

★ **Silver:** Observational studies (non-randomized trials, case-control, time-series, cohort studies, case series, literature reviews, qualitative studies).

☆ **Bronze:** Expert committee guidelines, reports or opinions, commentary or editorials.

● **Level of evidence** cannot be determined.

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2. Summary of Findings:

a. Continuous monitoring in pediatric non-critical inpatient units.

✳️ *A 2015 trial randomized infants to receive intermittent versus continuous monitoring upon general ward admission for bronchiolitis from the ER. The groups differed slightly, where the intermittent group was older, and received less corticosteroids and antibiotics in the ER prior to admission. The results demonstrated that there was no difference between groups in the length of stay following general ward admission. However, it is important to note some methodological issues with the study. Children in the intermittent group were placed on this monitoring frequency only if their SpO₂ was below 90%, in which case they were continuously monitored. It is unclear how many infants required this intervention. As well, in this same group, the SpO₂ was monitored when other vital signs were checked, though the frequency was not stated. The study did not have sufficient enrolment to make conclusions about other outcomes such as ICU transfers. Despite these limitations, the authors recommend “intermittent pulse oximetry monitoring can be routinely considered in the management of children hospitalized for bronchiolitis who show clinical improvement.” [5]*

★ *A 2015 nursing quality improvement project implemented algorithms to guide decision-making related to the use of pulse oximetry and oxygen in children with acute respiratory illness on a medical inpatient unit. The aim was to standardize care and to improve outcomes and health care costs. Spot check SpO₂ with VS was followed at determined intervals or as needed, established by the nurse. Continuous monitoring was used as a strategy only when severe symptoms were identified. Following the pilot implementation of the algorithms, they found a decrease in the use of continuous pulse*

oximetry, as well as spot pulse oximetry, a decrease in time on oxygen, as well as a decrease in length of stay with children diagnosed with bronchiolitis and asthma pre and post implementation. Significant cost savings were also recorded. The authors recommended “tailoring the algorithms for oxygen weaning and pulse oximetry to fit individual hospitals” and population needs. The study highlighted the importance of having clear procedures and response pathways related to the use of monitoring. [6]

★ *A 2015 report described 4 examples of death due to respiratory depression following opioid administration. In each example, the caregivers’ attributed inadequate or missing physiological monitoring as a cause for death. The article advocates for patient safety by implementing continuous monitoring for all patients on opioid medications when hospitalized. [7]*

b. Continuous monitoring on adult non-critical inpatient units

☼ *A 2015 systematic review examined the impact of continuous respiratory monitoring on general adult hospital wards. They explored whether there was an improvement over intermittent monitoring in the caregiver’s detection of deteriorating patients, and improved patient safety indicated by the number of critical events. A total of 6 intervention studies of moderate quality (including 2 RCTs) were reviewed. All the studies used different monitoring devices, but most evaluated oxygen saturation, and 3 evaluated breathing rate. 2 of the devices transmitted a wireless signal from the patient. Transmission of the signal to the health professional occurred through bedside, nursing beeper and/or central nursing station alarms and in one case, messages were sent to the responsible physician and nurse via a mobile phone. General wards included surgical, medical and cardiac wards where the nurse to patient ratio varied from 1:4 to 1:8. The primary outcome differed between studies and therefore the results could not be combined. These included ICU admissions, outreach team involvement, cardiopulmonary instability & arrest and death. In all reviewed studies, the incidence of the primary outcome was lowered, but not always significantly. A decrease in ICU length of stay was also not significant. Patient discomfort in 3 of the studies was not found to be a factor. And finally, alarm rates were mentioned in 4 studies and ranged from 0.03 to 4 alarms per patient per day. The authors concluded, “Implementation of routine continuous respiratory monitoring on general hospital wards cannot yet be advocated.” They call for more rigorous studies that investigate the multiple components of the intervention and outcomes. [3]*

c. Alarm Fatigue

★ *In 2014, a quasi-experimental study reported on the implementation of a standardized process for cardiac monitor care on a pediatric bone marrow transplant unit to improve the number of nuisance alarms while maintaining patient safety. A multidisciplinary team developed standards which included instituting age-appropriate parameters for patients upon placement on cardiac monitors, daily electrode changes, daily evaluation of cardiopulmonary monitor parameters and timely discontinuation of the monitors once the patients were no longer on patient-controlled analgesia and were stable. In addition, the alarm parameters for respiratory rate were increased, as was the alarm for SpO₂ delay from 5 to 10 seconds. After implementation, they described successfully decreasing the median number of false alarms from 90%- 50% and decreasing nursing time to attending to an alarm from 25 minutes to 10 minutes per shift. Families also reported high satisfaction to staff attending alarms. They did not provide specific numbers to address whether improvement of decompensation, code or staff emergencies was achieved. The study is unable to say with certainty what factor made the largest*

impact on the improvement seen, though the authors recommend a team-based approach for managing monitor care. [8]

★ A 2015 review article discussed the condition of alarm fatigue including the causes and risks to the patient associated with it. One of the main risks of alarm fatigue is the desensitization to frequent alarms causing a delayed or inadequate response. The causes are described as multifaceted and included organizational policies, out of date work processes and poor equipment performance. The authors suggested, “Any solution must not decrease the quality of surveillance and must be compliant with existing policies and regulations.” Some suggestions for interventions against alarm fatigue were discussed, including integrating smart alarms that report multiple parameters and are triggered by a combination of events versus a single parameter; implementing mobile devices for health care professionals that can display alarms from their patients; optimizing equipment; and finally, to audit the alarm quantity and type and develop a tailored plan to reduce no-actionable alarms. [4]

● The American Association of Critical-Care Nurses reported on 7 evidence-based recommendations to reduce alarm fatigue and improve patient safety. These included providing proper skin preparation for ECG electrodes; changing ECG electrodes daily; customizing alarm parameters and levels on ECG monitors; customizing delay and threshold settings on oxygen saturation via pulse oximetry monitors; provide initial and ongoing education about devices with alarms; establish interprofessional teams to address issues related to alarms such as the development of policies and procedures; and to provide monitoring only to those patients with appropriate clinical indications. The level of evidence supporting these recommendations was mostly low (case reports), and one well executed RCT (proper skin preparation for ECG electrodes). The article did not discuss issues of implementation. [9]

● A 2014 report argued for a solution on how to provide optimal surveillance to post-operative patients (adult population described). The article explained the three physiological pathways to rapidly evolving clinical cascades that are often deadly adverse events seen in postoperative hospitalized patients. The authors propose the Dartmouth-Hitchcock Medical center initiative called the Patient Surveillance System program to deliver continuous monitoring to all patients for their entire hospitalization on a general care floor. The program relied heavily on nursing education of warning signs as a critical step in early detection of adverse events. In addition, the program set their alarm threshold monitors for pulse oximetry at SpO₂ 80% and a Heart Rate threshold below 50 and above 140 bpm. The alarm signalled nurses via pagers, and allowed for response delays due to artifacts. However, a notification of violation of alarm response was implemented following a 30 second total delay. They described positive outcomes in terms of decreased mortality, patient transfers to the ICU and rescue events.[2]

d. Additional sources:

★ A 2011 review of the literature examined the impact of technology, including monitoring technology, on pediatric patients on general care units and their parents or other family caregivers. Following a broad literature scope, the authors described finding few articles that addressed the issue. They developed a theoretical model to illustrate the role of technology in the parent-child-nurse relationship. The model outlines a pathway where the nurse’s actions are grounded in the data provided by the

technology. For parents and children, the pathway is similar but seems to be more psychologically and emotionally complex. This may be due to parents not being trained in interpreting the technology and combining multiple parameters to make meaningful inferences. Parents may also find the setting and devices used unfamiliar. The authors contend that this may cause stress or discomfort for parents. They recommend that nurses provide “nurturing, supportive, and technologically adept care, while simultaneously facilitating the parent’s understanding about medical technology as it pertains to the hospitalized child.” [10]

★ *In 2010, a report explored the issue of enhancing patient safety through a review of nurses’ knowledge and skills for measuring physiological parameters, the use of electronic monitoring and the use of an early warning score in a general hospital ward culture. The article highlighted the importance of recognizing the respiratory rate as a sensitive indicator for clinical deterioration and recommends that nurses have regular skill maintenance for recognizing adverse events. Another recommendation is that a qualified nurse bases the frequency and type of observations on the needs identified during an individual assessment of the patient. [11]*

● *The Joint Commission in 2014, which is an accreditation body for health care organizations in the United States, launched a National Patient Safety Goal to combat Alarm Fatigue in American hospitals and critical care centres. A two phase approach will focus on prioritizing the reduction of alarm in each centre and to identify the alarms to manage, and then to development policies around management of the alarms. Visit http://www.jointcommission.org/assets/1/18/jcp0713_announce_new_nspg.pdf for more information.*

3. References:

1. Burgess, L.P., et al., *Alarm limit settings for early warning systems to identify at-risk patients.* Journal of Advanced Nursing, 2009. **65**(9): p. 1844-52.
2. Curry, J.P. and C.R. Jungquist, *A critical assessment of monitoring practices, patient deterioration, and alarm fatigue on inpatient wards: a review.* Patient Saf Surg, 2014. **8**: p. 29.
3. van Loon, K., et al., *Non-Invasive Continuous Respiratory Monitoring on General Hospital Wards: A Systematic Review.* PLoS One, 2015. **10**(12): p. e0144626.
4. Ruskin, K.J. and D. Hueske-Kraus, *Alarm fatigue: impacts on patient safety.* Curr Opin Anaesthesiol, 2015. **28**(6): p. 685-90.
5. McCulloh, R., et al., *Use of Intermittent vs Continuous Pulse Oximetry for Nonhypoxemic Infants and Young Children Hospitalized for Bronchiolitis: A Randomized Clinical Trial.* JAMA Pediatr, 2015. **169**(10): p. 898-904.
6. Martin, S., J. Martin, and T. Seigler, *Evidence-Based Protocols to Guide Pulse Oximetry and Oxygen Weaning in Inpatient Children with Asthma and Bronchiolitis: A Pilot Project.* J Pediatr Nurs, 2015. **30**(6): p. 888-95.
7. Williams, J., *Saving lives, saving families: continuous monitoring for patients on opioids.* Biomedical Instrumentation & Technology, 2015. **49**(1): p. 40-4.

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8. Dandoy, C.E., et al., *A team-based approach to reducing cardiac monitor alarms*. *Pediatrics*, 2014. **134**(6): p. e1686-94.
9. Anonymous, *Alarm management*. *Critical Care Nurse*, 2013. **33**(5): p. 83-6.
10. Dunn, K. and R. Board, *Parents and technology in the inpatient pediatric setting: a beginning model for study*. *Pediatric Nursing*, 2011. **37**(2): p. 75-80.
11. Preston, R. and D. Flynn, *Observations in acute care: evidence-based approach to patient safety*. *British Journal of Nursing*, 2010. **19**(7): p. 442-7.

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