# Pulse oximetry and the enduring neglect of respiratory rate assessment: a commentary on patient surveillance

Malcolm Elliott and Jill Baird

## ABSTRACT

Clinical surveillance provides essential data on changes in a patient's condition. The common method for performing this surveillance is the assessment of vital signs. Despite the importance of these signs, research has found that vital signs are not rigorously assessed in clinical practice. Respiratory rate, arguably the most important vital sign, is the most neglected. Poor understanding might contribute to nurses incorrectly valuing oxygen saturation more than respiratory rate. Nurses need to understand the importance of respiratory rate assessment as a vital sign and the benefits and limitations of pulse oximetry as a clinical tool. By better understanding pulse oximetry and respiratory rate assessment, nurses might be more inclined to conduct rigorous vital signs' assessment. Research is needed to understand why many nurses do not appreciate the importance of vital signs' monitoring.

**Key words:** Clinical assessment ■ Pulse oximetry ■ Respiratory rate

**N**ursing surveillance is essential for patient safety and outcomes (Kelly and Vincent, 2011). The common method for performing this surveillance is the rigorous assessment of vital signs. These signs provide critical data on the patient's response to treatment and feedback on changes in their condition. When vital signs are assessed accurately, clinical deterioration can be identified early and responded to expediently, providing the opportunity to reduce or avoid patient mortality (Bleyer et al, 2011; Flenady et al, 2017). This can only occur, however, if nurses understand the physiological basis and importance of vital signs and that these signs are assessed, communicated and acted upon (Armstrong et al, 2008).

Although vital signs' assessment provides important clinical data, research has consistently found the routine assessment, documentation and interpretation of these signs

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is frequently neglected (Hogan, 2006; Yeung et al, 2012). In an analysis of 79 patient assessments on two specialty wards in an Australian hospital, for example, a full set of vital signs (defined as temperature, pulse, blood pressure, respiratory rate and oxygen saturation) was measured only 21% of the time (Cardona-Morrell et al, 2016). It was speculated that numerous factors influence vital signs' assessment such as nurses' clinical judgement, time constraints and work distractions. Similar neglect of vital signs has been found in other research. In an audit of 241 adult cardiac arrests in a UK hospital, nurses failed to adhere to early warning score protocols in half of the cases; this protocol included interpreting and reporting vital signs (Odell, 2015).

## Respiratory rate

Respiration, the process of breathing in and out, is the primary function of the lungs. The purpose of this process is to bring oxygen into the body for delivery to the cells, and to remove carbon dioxide, a byproduct of cellular respiration (Thiriet, 2014). Respiratory rate is measured by manually counting the patient's rate for 1 minute without their awareness (Tollefson and Hillman, 2019). It is one of the few vital signs that is not easily measured by a monitor.

Respiratory rate has been labelled the most important vital sign as it is the most sensitive indicator of acute deterioration (Cahill et al, 2011). It is the most sensitive vital sign for determining illness acuity as it provides more discriminating evidence of clinical deterioration than other vital signs (Smith et al, 2011; Barfod et al, 2012). Respiratory rate is an early indicator of hypoxia, hypercapnia, and metabolic and respiratory acidosis (Rolfe, 2019). If there is a change in the patient's cardiac or neurological status, respiratory rate is often the first vital sign affected (Liddle, 2013).

Despite its clinical importance, research has found that respiratory rate is the most clinically neglected vital sign in terms of whether it is accurately assessed and documented (Chen et al, 2009). In an observational study of recorded versus directly observed respiratory rates in 368 inpatients in North America, nurses' recorded respiratory rates did not correspond with those directly observed by researchers (Semler et al, 2013). To compound this negligence, the recorded respiratory rates were consistently documented as significantly higher than

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the actual rate, at 18–20 breaths per minute (Semler et al, 2013). It was suggested that as all other vital signs can be easily measured with an automated device, respiratory rate might actually be estimated by clinicians as it requires manual measurement, which introduces user bias (Semler et al, 2013). Another retrospective study of 204 patients experiencing a life-threatening adverse event in the Netherlands, found that most patients had incomplete assessment of vital signs; respiratory rate was documented in only 23% of cases (Ludikhuize et al, 2012).

Although many studies have highlighted the poor assessment of respiratory rate, few have explored the reasons for this (Flenady et al, 2017). Those that have, used qualitative methods, identifying various reasons such as 'it cannot be assessed by a machine', 'the patient looks stable', lack of time, and laziness (Hogan, 2006; Philip et al, 2013; Ansell et al, 2014). This suggests that many nurses do not understand the importance of respiratory rate as a vital sign. In a study of 79 Australian emergency department nurses, a common belief was that counting respiratory rates at each round of vital signs' assessment was superfluous to patients' needs and a waste of valuable time (Flenady et al, 2016). These nurses reported that recording an accurate respiratory rate was not a priority unless the patient was exhibiting signs of respiratory distress, was a paediatric patient or had a history of respiratory illness (Flenady et al, 2016).

## Pulse oximetry

Pulse oximetry measures oxygen saturation in peripheral arterial blood—$SpO_2$ (Urden et al, 2017). This reflects a ratio between the oxygen content of haemoglobin and the potential oxygen carrying capacity of haemoglobin (Van Leeuwin and Bladh, 2015). Importantly the $SpO_2$ does not reflect the adequacy of ventilation nor necessarily reflect tissue oxygen delivery (Pretto et al, 2014). It is not a surrogate marker of respiratory rate (Rolfe, 2019). It is possible, for example, for the $SpO_2$ to be normal but the respiratory rate to be increased due to hypercapnia (Parkes, 2011).

Since its introduction in the early 1980s, pulse oximetry has become a ubiquitous clinical monitoring device widely used to inform patient care and improve outcomes (Milner and Mathews, 2012). Pulse oximetry plays an important role in monitoring hypoxaemia and the early detection of patients at high risk of deterioration, and is effective in guiding oxygen therapy in adult and paediatric patients (Pretto et al, 2014). A recent systematic review found that pulse oximetry can reduce mortality rates and length of emergency department stay and change physicians' decisions on illness severity, diagnosis and treatment (Enoch et al, 2016).

Despite being a valuable clinical tool, nurses' understanding of the purpose of pulse oximetry and what it reveals about the patient is often poor. In a recent survey of 300 newly graduated nurses in Australia, for example, only 44% knew that oxygen saturation ($SpO_2$) is not an indicator of adequate ventilation (Seeley et al, 2015). Nearly half of these nurses incorrectly believed that an $SpO_2$ of 90% corresponds with a partial pressure of oxygen of 90 mmHg (Seeley et al, 2015). These findings, however, are not limited to graduate nurses.

In a survey of 198 intensive care, emergency and anaesthesia nurses in Serbia, the majority of participants did not know that tissue hypoxia could not be reliably detected by pulse oximetry (Milutinovic et al, 2016). More than half of these specialist nurses were also not aware that pulse oximetry is not a reliable indicator of adequate ventilation (Milutinovic et al, 2016). Similar findings were identified in a survey of 114 intensive care and emergency nurses in Turkey (Celik et al, 2014). Most of these nurses did not have the knowledge required to correctly use pulse oximetry (Celik et al, 2014). The findings of these studies suggest that at the graduate and postgraduate levels, many nurses lack the knowledge to meaningfully interpret pulse oximetry readings and, thus, incorrectly use it to guide clinical practice.

Of concern is that these contemporary research findings are consistent with older studies on this issue. In a survey of 331 registered nurses working at an acute medical centre in North America, one-third could not indicate what a pulse oximeter actually measures (Attin et al, 2002). Research in other countries had similar results (Bader, 2007; Nikfarid et al, 2008). The findings of these contemporary and older studies raise the question of why nurses' understanding of pulse oximetry is poor despite it being heavily relied on to guide clinical practice, and furthermore, why nurses' understanding of oximetry has not improved over time.

The importance of respiratory rate and $SpO_2$ as vital signs can be seen in a case study of an 80-year-old patient with pneumonia and suspected sepsis (Wheatley, 2018). The patient's baseline respiratory rate was within normal range (20 breaths/minute) but the $SpO_2$ slightly low (93%). Four hours later, as his condition deteriorated, the respiratory rate increased to 28 breaths/minute but the $SpO_2$ dropped only slightly (91%). The case study emphasises the importance of respiratory rate as a vital sign and early predictor of clinical deterioration (Wheatley, 2018). It also demonstrates that $SpO_2$ may remain relatively normal due to an increase in respiratory rate compensating for inadequate oxygen delivery (Dix, 2018).

## Pulse oximetry and respiratory rate measurement

Research has not established that the use of pulse oximetry has contributed to the neglect of respiratory rate assessment. However, poor understanding of pulse oximetry and respiratory rate assessment might be associated with nurses favouring the measurement of $SpO_2$ over respiratory rate. A lack of understanding might result in nurses incorrectly believing that oxygen saturation is a more important or valuable vital sign, resulting in the neglect of respiratory rate assessments. Similarly, as oxygen saturation is measured by an automated machine while respiratory rate is counted manually, nurses might incorrectly assume $SpO_2$ is of greater clinical significance. Although this link is not clear, research has consistently found that many nurses do not know how to use a pulse oximeter nor appreciate the importance of respiratory rate assessment (Nikfarid et al, 2008; Milutinovic et al, 2016).

A failure to understand the clinical importance of vital signs' assessment and interpretation might contribute to some

## KEY POINTS

- Abnormal vital signs are associated with adverse events and poor outcomes
- Pulse oximetry is a common tool for assessing oxygen saturation
- Respiratory rate assessment is often neglected in clinical practice
- Poor understanding of pulse oximetry and the importance of respiratory rate assessment might result in the neglect of respiratory rate assessment

vital signs being incorrectly valued more than others. In a study of 380 ward nurses in Singapore, more than half the nurses relied solely on $SpO_2$ to evaluate respiratory dysfunction and over one-quarter made quick estimates of respiratory rates (Mok et al, 2015). Nearly one-quarter of these nurses considered vital signs' monitoring to be time consuming and one-third found it to be overwhelming (Mok et al, 2015). Nurses' attitudes towards vital signs' monitoring, however, have not been adequately researched. More research is needed to determine whether nurses' misunderstanding of vital signs is a global problem and most importantly what the best strategy is for addressing this issue.

## Implications for nursing

Worldwide, various initiatives have emerged to help identify and improve the management and outcomes of the acutely deteriorating patient. These include medical emergency or rapid response teams, early warning scores or digital software with in-built algorithms. The success of such initiatives is highly dependent on the timely recognition and response to deterioration, which relies on nurses accurately assessing and recording vital signs (Moriarty et al, 2014). If nurses believe that some vital signs are less important than others, thorough assessment of these signs might not occur, resulting in frequent or delayed activation of emergency initiatives and thus, poorer patient outcomes. Not surprisingly, most studies exploring the neglect of respiratory rate assessment identified inconsistent or a lack of basic education about vital signs (Philip et al, 2013; Ansell et al, 2014).

## Conclusion

The neglect of vital signs' assessment is a critical issue for patient safety, care quality and clinical outcomes. Nurses' reliance on a poor understanding of pulse oximetry might contribute to the neglect of respiratory rate assessments. More research is

needed to understand why many nurses do not appreciate the importance of vital signs' monitoring; to date, few studies have explored this issue. **BJN**

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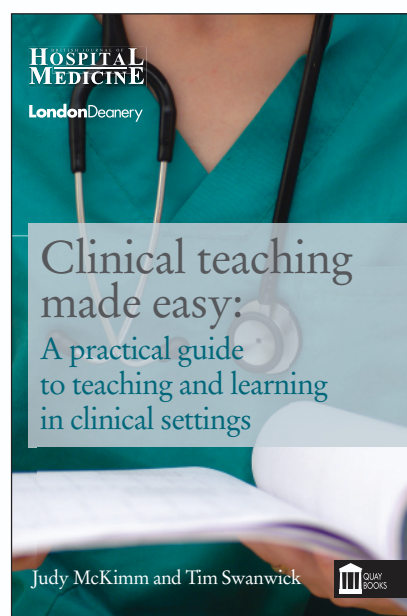
## CPD reflective questions

- Why is vital signs' assessment neglected in clinical practice?
- Why is respiratory rate arguably the most important vital sign?
- How can pulse oximetry be used to guide clinical management?
- How can pulse oximetry mislead decision making?

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