What is the nursing time and workload involved in taking and recording patients' vital signs? A systematic review

ABSTRACT

Aims and objectives: To synthesise evidence regarding the time nurses take to monitor and record vital signs observations, and to calculate early warning scores (EWS).

Background: While the importance of vital signs' monitoring is increasingly highlighted as a fundamental means of maintaining patient safety and avoiding patient deterioration, the time and associated workload involved in vital signs activities for nurses are currently unknown.

Design: Systematic review.

Methods: A literature search was performed up to 17 December 2019 in CINAHL, Medline, EMBASE, and the Cochrane Library using the following terms: vital signs; monitoring; surveillance; observation; recording; early warning scores; workload; time; and nursing. We included studies performed in secondary or tertiary ward settings, where vital signs activities were performed by nurses, and we excluded qualitative studies and any research conducted exclusively in paediatric or maternity settings. The study methods were compliant with the PRISMA checklist.

Results: Of 1,277 articles, we included 16 papers. Studies described taking vital signs observations as the time to measure/collect vital signs and time to record/document vital signs. As well as mean times being variable between studies, there was considerable variation in the time taken within some studies as standard deviations were high. Documenting vital signs observations electronically at the bedside was faster than documenting vital signs away from the bed.

Conclusions: Variation in the method(s) of vital signs measurement, the timing of entry into the patient record, the method of recording, and the calculation of EWS values across the literature makes direct comparisons of their influence on total time taken difficult or impossible.

Relevance to clinical practice: There is a very limited body of research that might inform workload planning around vital signs observations. This uncertainty means the resource implications of any recommendation to change the frequency of observations associated with early warning scores are unknown.

KEYWORDS

Vital Signs; Nursing; Monitoring; Early Warning Scores;

INTRODUCTION

Patients' vital signs and associated trends are accurate predictors of clinical deterioration (Brekke, Puntervoll, Pedersen, Kellett, & Brabrand, 2019; Churpek, Adhikari, & Edelson, 2016; Kause et al., 2004), and a failure to monitor them is associated with adverse patient outcomes, including death (Hogan et al., 2012; National Patient Safety Agency, 2007a). Often the measured vital signs values are used within aggregate early warning scoring systems to provide a single numerical assessment of the patient's risk of deterioration – an early warning score (EWS) (e.g. the National Early Warning Score, NEWS) (Royal College of Physicians, 2017). Measuring and recording vital signs, and calculating a EWS, are fundamental aspects of nursing work in acute care hospitals (Odell, Victor, & Oliver, 2009; Rose & Clarke, 2010). However, these activities are often incomplete (Mok, Wang, Cooper, Ang, & Liaw, 2015; National Patient Safety Agency, 2007b; Odell, 2015) or sometimes omitted completely (Palese et al., 2015; Schubert et al., 2013; Wood, Chaboyer, & Carr, 2019; Zander, Dobler, Baumler, & Busse, 2014), with inadequate nurse staffing (Griffiths, Ball, et al., 2018; Griffiths, Recio-Saucedo, et al., 2018; Odell, 2015) or long nursing shifts (Dall'Ora et al., 2019) cited as possible underlying reasons.

This raises the question of what the workload associated with taking vital signs observations is, and it highlights the importance of understanding the costs and benefits of changes in vital signs observation frequency. A recent systematic review found that implementing continuous monitoring in acute wards outside of intensive care units (ICU) is feasible and may improve patient safety, however the cost-effectiveness of such an approach is still unknown (Downey, Chapman, Randell, Brown, & Jayne, 2018). Current guidance on the recommended frequency of vital signs collection is supported by minimal empirical evidence (G. B. Smith, Recio-Saucedo, & Griffiths, 2017), and has largely been based on expert opinion (Devita, 2010; Miltner, Johnson, & Deierhoi, 2014; National Institute for Health Care Excellence, 2007). While the evidence broadly points towards benefits from more frequent observations, the absence of precise guidance combined with uncertainty about the resources required makes comparison between alternative strategies difficult.

The precise contribution that measuring and recording vital signs makes to overall nurse and nursing assistant workloads is unknown. However, it will depend upon (a) the time taken to collect and document the vital signs; (b) the number of patients in a given clinical area needing to have vital signs measured at any one time; and (c) the chosen frequency of measurements for individual patients, which is dictated by clinical opinion and/or national policy (National Institute for Health Care Excellence, 2007; G. B. Smith et al., 2017). This is summarised in Figure 1.

AIMS

This review aims to summarise the evidence regarding the time required for nurses to monitor and record a set of vital signs, in order to understand the nursing workload involved.

METHODS

Search strategy

We undertook a literature search from inception until 17 December 2019 to identify quantitative studies reporting the time spent by members of the nursing workforce (i.e., registered and licensed nurses, nursing assistants and equivalent roles – henceforth referred to as "nursing staff") in undertaking vital signs observations, the length of time to take a set of observations or factors that influenced the time taken. The study methods were compliant with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist (see Supplementary File 1).We searched CINAHL, Medline, EMBASE and the Cochrane Library using the following search terms: vital signs; monitoring; surveillance; observation; recording; early warning scores; workload; time; and nursing (See Supplementary File 2 search strategy). The search strategy was agreed by all authors and one author conducted the search.

Inclusion and exclusion criteria

We included studies that provided an evaluation of the time spent by members of the nursing workforce in gathering and recording any of the following vital signs (which are those included in NEWS) (Royal College of Physicians, 2017). These are: heart (or pulse) rate; respiration rate; body temperature; blood pressure (BP); level of consciousness; peripheral oxygen saturation (S_pO_2), and the inspired gas (air or oxygen) at the time of S_pO_2 measurement (Royal College of Physicians, 2017). Because we anticipated that we would find limited evidence, we decided not to exclude studies that were not explicit in reporting which vital signs were being measured, provided that the focus appeared to be on these 'standard' observations. We focused on adult secondary and tertiary care ward settings, excluding studies exclusively in paediatric or maternity settings, as the necessary vital signs measurements are often different for these populations. We excluded qualitative only studies, as our review question was quantitative in nature (i.e. time involved in vital signs activities). We retained studies that included other observations (e.g. patient weight, urine output) within the total times offered, as long as any or all of the components of NEWS were measured.

Data selection

One reviewer conducted the first screening of titles and abstracts for relevance. Two reviewers independently assessed the list of potentially relevant studies and identified studies for inclusion; any disagreements were resolved by discussion.

For quality appraisal, we focussed on describing key aspects of the study likely to affect the validity of the results including design, the methods of observation and recording, the vital signs observed and the setting and sample sizes using a framework based on the Joanna Briggs Institute Critical Appraisal checklist for descriptive / case series. (Munn, Moola, Riitano, & Lisy, 2014) Items that were not applicable to the main study question (such as confounding) were omitted from the checklist. The checklist comprises some items relating to risk of bias, and some concerning adequate reporting and statistical analysis, and poses questions to which possible answers are “no”, “yes”, and “unclear”. A response of “no” or “unclear” to any of the questions implies lower quality or else insufficient detail to judge the quality of a study. The checklist was completed by two reviewers, and one further reviewer resolved any disagreements. We did not exclude any studies based on their quality.

Data extraction

We extracted the following data from included studies: country; study design; sample size and setting; methods of vital signs measuring and recording; data collection; results; vital signs definition; mean (minutes); standard deviation (minutes).

Data analysis

Where authors reported only mean and 95% confidence intervals, we calculated the standard deviation as: ($\sqrt{n}$*(upper limit – lower limit)/t-value*2), where n is the sample size, upper limit and lower limit are those from confidence intervals. If the sample size is >100, the 95% confidence interval is 3.92 standard errors wide. We initially considered conducting a meta-analysis, but the high heterogeneity between studies, in terms of sample sizes, settings, and vital signs timing measurements, rendered this unfeasible.

RESULTS

The database search retrieved 1,277 papers, of which 11 studies met the inclusion criteria. An additional five studies were identified from the reference lists of papers accessed in full text (n= 59). The article screening and selection process is reported in Figure 2.

The results of all 16 included studies are summarised in Table 1 - Summary of selected studies (N= 16).

(Table 1 here)

Overall, the quality of the reports was low, with unclear reporting and significant limitations across many items in most studies (see Table 2 – Quality Appraisal of Studies). No study reported any reliability assessment of their measure of time, and no study scored a positive response to all remaining items on the checklist.

(Table 2 here)

Design of studies

Five publications were described as before-and-after studies (Bellomo et al., 2012; Fuller, Fox, Lake, & Crawford, 2018; Ito et al., 1997; McGrath, Perreard, Garland, Converse, & Mackenzie, 2019; Wong et al., 2017), mostly evaluating the impact of introducing automatic electronic vital signs systems or continuous vital signs monitoring. Ten studies were classified as descriptive observational (Adomat & Hicks, 2003; Clarke, 2006; Hendrich, 2008; Hoi, Ismail, Ong, & Kang, 2010; Kimura, Nakai, & Ishihara, 2016; Travers, 1999; Wager et al., 2010; Yeung, Lapinsky, Granton, Doran, & Cafazzo, 2012; Zeitz, 2005; Zeitz & McCutcheon, 2006), and one study was a pilot study of a bedside clinical information system (Erb & Coble, 1989).

Most (n= 11) used time-and-motion methodologies (Adomat & Hicks, 2003; Fuller et al., 2018; Hendrich, 2008; Hoi et al., 2010; McGrath et al., 2019; Travers, 1999; Wager et al., 2010; Wong et al., 2017; Yeung et al., 2012; Zeitz, 2005; Zeitz & McCutcheon, 2006). In eight studies, researchers collected data by directly observing nursing staff (Hoi et al., 2010; McGrath et al., 2019; Travers, 1999; Wager et al., 2010; Wong et al., 2017; Yeung et al., 2012; Zeitz, 2005; Zeitz & McCutcheon, 2006). One study used data from a video recording of 48 continuous shifts (Adomat & Hicks, 2003). Another plotted the number of steps that nurses took from the bedside to the computer when documenting vital signs in addition to measuring the time taken to complete and record vital signs observation using time-and-motion methodology (Fuller et al., 2018). In three studies, nurses were asked to estimate the time they had taken to complete vital signs observations. (Clarke, 2006; Hendrich, 2008; Ito et al., 1997) In one of these studies, nurses noted the time taken to complete vital signs for each patient and calculated the total time spent on this activity. (Ito et al., 1997) In one time-sampling study, nurses were asked to report the activity they were engaged in when a personal digital assistant (PDA) they were carrying vibrated at random times during the shift (Hendrich, 2008). As indicated in Table 2, seven studies did not provide a clear description of how time to complete a set of vital signs was assessed; among these, three studies did not give any meaningful detail about how the time to complete a set of vital sign

observations had been collected (Bellomo et al., 2012; Erb & Coble, 1989; Kimura et al., 2016). Among these, one study was available as abstract only (Kimura et al., 2016).

Setting of studies

Coverage of settings ranged from one to thirty-six hospital wards of various types, namely: acute surgical/medical general wards, ICU, an emergency department, a cardiovascular unit, a trauma ward, and a radiology unit. One study did not specify the type of hospital or which wards were included (Kimura et al., 2016).

Methods of vital signs measurement

The 16 studies generally described taking vital signs observations as the time to measure/collect vital signs and the time to record/document vital signs. However, the specific set of vital signs chosen for measurement differed by study, which inevitably affected the overall time taken. Some included seven different physiological signs in a complete vital signs set (Wong et al., 2017), while others included only four (Kimura et al., 2016). All studies reporting physiological signs measured temperature, heart rate, respiration rate, blood pressure (Bellomo et al., 2012; Erb & Coble, 1989; Fuller et al., 2018; McGrath et al., 2019; Travers, 1999; Wager et al., 2010; Wong et al., 2017; Yeung et al., 2012; Zeitz, 2005; Zeitz & McCutcheon, 2006). Some studies offered no specific description of the vital signs collected (Adomat & Hicks, 2003; Hendrich, 2008; Hoi et al., 2010; Ito et al., 1997). Also, studies did not always specify whether only complete sets of vital signs had been included for analysis. A number of studies included additional observational and assessment activities in the time taken to complete vital signs, such as completing fluid balance charts, checking infusion pump, and weighing the patient (Bellomo et al., 2012; Erb & Coble, 1989). The measurement tools did not vary substantially across the years.

Methods of time recording

In general, the time involved in vital signs recording and documenting was reported in two different ways. A number of studies reported a mean time for taking a vital signs set, mean time to record vital signs on charts, or both (Bellomo et al., 2012; Clarke, 2006; Ito et al., 1997; Kimura et al., 2016; McGrath et al., 2019; Travers, 1999; Wager et al., 2010; Wong et al., 2017; Zeitz, 2005; Zeitz & McCutcheon, 2006). Other studies reported the amount of time that nursing staff spent taking vital signs and/or recording them over a shift, per hour, per patient, or over an amount of time (e.g. over 44.5 hours). (Adomat & Hicks, 2003; Erb & Coble, 1989; Fuller et al., 2018; Hendrich, 2008; Hoi et al., 2010; Yeung et al., 2012) None attempted to disentangle the time taken to collect or document each vital sign (i.e. blood pressure or oxygen saturations or respiration rate) or EWS value separately.

(Table 3 here)

Studies reporting mean times

Ten studies provided a total of twelve samples to estimate mean times for taking and/or recording vital signs (see Table 3) . When studies investigated the time involved in measuring and documenting vital signs using pen and paper methods, mean times ranged from 3.58 minutes (Wong et al., 2017) to 5.80 minutes (Zeitz, 2005; Zeitz & McCutcheon, 2006). When documentation was performed using electronic systems, mean times for measurement and documentation were lower at 2.50 minutes in both studies (Bellomo et al., 2012; Wong et al., 2017). We did not find any differences in mean times involved in vital signs measuring and documenting that could be attributed to different clinical settings, nor to different nursing personnel (i.e. registered nurses vs nurse assistants). Differences in mean times appeared to be related to the combination of vital signs included within the recorded dataset; the method(s) of vital signs measurement; the timing of entry into the patient record; the method of recording; the calculation of EWS values. As well as mean times being variable between studies, it was clear that there was considerable variation in the time taken within some studies, as standard deviations were high.

All studies where reported times focused only on vital signs documentation involved continuous patient monitoring and focused on electronic systems of data transfer to the patient record. Electronic systems where vital signs were entered at the bedside seemed to be associated with reduced time. The mean times to document vital signs observations electronically at the bedside ranged from 0.90 (Ito et al., 1997) to 1.27 minutes (Kimura et al., 2016), and mean time for documenting vital signs outside the bed space was between 1.47 minutes (Kimura et al., 2016) and 2.02 minutes (Ito et al., 1997). One study focused on the mean time difference between the time vital signs were taken and when the data were recorded in the patient's record, and found that when staff were recording data on a vital signs monitor at the bedside and transferring them to a PC tablet the mean difference was 0.59 minutes; when vital signs observations were transcribed from handwritten notes to patient notes the mean difference was 1.24 minutes; and for handwritten observations to be transferred to a computer on wheels outside the bed space, the latency time was 9.15 minutes (Wager et al., 2010).

Studies which do not provide mean time estimates

Four studies reported the time involved in collecting and recording vital signs by hour or by nursing shift (Adomat & Hicks, 2003; Hendrich, 2008; Hoi et al., 2010; Yeung et al., 2012). Hoi et al. found it took 144 minutes of total nursing time per day for a patient in the most

highly acute and dependent category, where assistance with all care needs and multiple treatments were often required (Hoi et al., 2010). Adomat et al. showed that charting observations and record keeping in two units ranged from a mean average of 5.44 to 10.78 minutes per hour in an HDU and from 10.66 to 17.43 min/hr in ICU (Adomat & Hicks, 2003). Hendrich et al. showed that vital signs took up 7.2% of nursing time or 30.9 minutes in a 10-hour shift (Hendrich, 2008). According to Yeung et al., the total time spent by each nurse performing vital signs observations was on average 12 minutes, albeit the unit of observation was not reported (i.e. per hour, per shift, or per patient) (Yeung et al., 2012).

Erb and Coble reported vital signs documentation on a new automated system, where nurses record all vital signs at the bedside using a monitor that measures blood pressure, pulse rate and temperature (Erb & Coble, 1989). Vital signs data are stored on a computer at the nurse station unit, and the bedside unit and nurse station unit are connected directly. The authors compared this system to an older manual system, and found that it offered an overall mean time saving per nurse per shift of 11.86 minutes (Erb & Coble, 1989). Fuller et al. reported that the time taken to document vital signs in a computer was seven minutes per ten patients (Fuller et al., 2018) suggesting a mean time below that of any study reporting a per patient time above.

DISCUSSION

This is the first systematic review of evidence to identify the amount of nursing time required to take vital signs observations. We found sixteen studies that evaluated the time taken by nursing staff to perform and/or record vital signs observations. Studies varied considerably in their time estimates, although most estimates demonstrate the potential for this activity to occupy a considerable amount of nursing time, especially if undertaken with high frequency. However, this variation and uncertainty in the evidence means that we were unable to give a reliable estimate of time taken. A variety of factors influence the times taken to complete vital signs observations and, while the studies illustrate these factors, they are inconsistently and incompletely recorded in the literature, making direct comparisons of their influence on total times difficult or impossible.

We identified a number of key variables related to overall times recorded in the studies:

- The combination of *vital signs* included within the recorded dataset
- The method(s) of vital signs *measurement*
- The *timing* of entry into the patient record
- The method of *recording*

- The c*alculation* of EWS values

Across studies, there was variation in the dataset of *vital signs* measured each time, as these are often determined by local guidance. There was also variation in the *methods of measurement* of vital signs observations. Some vital signs (e.g., heart rate and respiratory rate) can be measured manually (i.e., without the use of equipment) or automatically using devices/monitors. Some parameters (e.g., consciousness level) can only be measured on general wards using manual techniques, whilst others (e.g. S_pO_2) can only be measured using an electronic monitor. Studies considered in this review either involved a mixture of manual and automatic methods of measuring vital signs or did not clearly report them (see (Adomat & Hicks, 2003; Hendrich, 2008; Hoi et al., 2010; Ito et al., 1997).

A further source of variation seen in the papers described in this review was the *timing of entry* of measured vital signs data into charting systems. Nursing staff entered data either in real-time at the patient's bedside (Bellomo et al., 2012; Erb & Coble, 1989; Fuller et al., 2018; Ito et al., 1997; McGrath et al., 2019) or after leaving the bedside (i.e. delayed) (Wager et al., 2010; Wong et al., 2017; Yeung et al., 2012). In some studies, vital signs data were entered in real-time at the bedside on paper charts, and in others they were manually entered on electronic or paper medical records after collection. However, in the papers reviewed here, when data were recorded at the bedside, it was mostly done using hand-held electronic devices, where data was either uploaded automatically or required the nurse to physically transfer data to a central database using a wired system. Results from studies where real-time electronic systems had been introduced showed a reduction in the time involved in vital signs monitoring and recording compared to traditional paper-based methods, especially if the latter required further transcribing at the end of the observation sessions.

In the papers we studied, there was little indication of the approach to the *calculation of EWS values* even though determination of risk based on vital signs is now seen as an important function of taking the observations (G. B. Smith et al., 2017). It would be possible for these to be calculated manually (i.e., without using a device), using a device such as a calculator; within a free-standing, mobile app; or automatically using a hand-held device or as part of the data measurement/entry system. In this review, two studies reported that the electronic systems being piloted were designed to calculate EWS values automatically after the entry of vital signs data.(Bellomo et al., 2012; Wong et al., 2017) In both studies, the EWS values were displayed on the electronic systems alongside clinical advice (e.g. escalation to a doctor or rapid response team) based on the automatically calculated EWS value. Previous

studies reported that calculation of EWS with hand-held devices improves accuracy of EWS values (Mohammed, Hayton, Clements, Smith, & Prytherch, 2009) and saves nursing time, with one study reporting that using a programmed digital assistant (i.e. VitalPAC™) was on average 1.6 times faster than using the traditional pen and paper method (Prytherch et al., 2006).

The workload involved in vital signs activities for nursing staff is potentially significant (Clarke, 2006; Zeitz, 2005; Zeitz & McCutcheon, 2006) with important clinical consequences. However, we have shown that there is a very limited body of research that might inform workload planning. The studies surveyed here also highlight that there is currently no standardised way of measuring vital signs workload or interpreting it. Several publications affirm that failure to engage with vital signs activity leads to adverse patient outcomes, including mortality (Churpek et al., 2016; Devita et al., 2006; Osborne et al., 2015). Nursing staff have previously reported that workload is an important factor in the timeliness and ability to observe patients regularly (Mok et al., 2015; D. J. Smith & Aitken, 2016), so that the absence of reliable evidence to determine the workload involved with vital signs observations is surprising. This is of particular importance, especially as vital signs monitoring and recording is regarded as a fundamental component of nursing care. Clinical guidelines recommending the frequency of vital signs observations do not take into account the time required to complete them (National Institute for Health Care Excellence, 2007; Royal College of Physicians, 2017).

If nursing staff perceive the vital signs workload as excessive, they may choose to prioritise other activities and follow their clinical judgement rather than an observation schedule dictated by a protocol (Hope et al., 2018) At present, there is no evidence to determine whether the nursing workforce is sufficient to accommodate existing demand - or potentially an increase in demand - arising from increasing compliance with current observation protocols, or from changing such protocols because the demand is not clearly quantified. Based on the current literature we cannot yet tell whether observations for all patients in a 30-bed unit might require an hour of work (2 minutes per patient) or two and a half hours (5 minutes per patient) or indeed considerably more or less if these estimates are inaccurate, or sub-optimal systems are in place.

The investigation of time and workload involved in taking vital signs observations activities has focused mainly on reporting average times. However, mean times varied substantially due to different physiological parameters being measured across studies and, where reported, different methods of measurement and vital signs documenting. Future research

that can determine the workload associated with nurses' activities around vital signs observations is warranted. Future studies should be more explicit in describing contexts and systems in use. In particular for new electronic systems it would be worthwhile establishing how accessible it is for nursing staff to observe vital signs observation trends of their patients and how accessible these systems are for temporary staff.

Limitations

In appraising studies, we applied a checklist based on the Joanna Briggs Institute Critical Appraisal checklist for descriptive / case series (Munn et al., 2014), and all studies were of low quality. We highlighted key omissions of important details, for example which vital signs were included and how they were measured and recorded, or how were nurses and/or patients sampled. The results of the review illustrate the variety of factors that may influence the time estimates derived from the studies and demonstrate where information is missing. Whilst we used a reproducible search strategy searching MEDLINE, CINAHL, EMBASE and the Cochrane Library, it is possible that we did not identify studies indexed elsewhere and not cited by the included studies. It seems unlikely that these exist in sufficient quantity to substantively change our conclusions.

CONCLUSIONS

There is currently insufficient robust evidence around the time nurses require to perform vital signs activities. To increase consistency and impact, we propose a framework for future studies to adopt measuring the time and workload involved in vital signs observations that includes (a) the methods of measurements, (b) the timing of entry of measured data into charting system and (c) the approach to calculation of EWS values. This categorisation would be suitable for vital signs measured on an individual patient basis, or on the basis of vital signs "rounds", where the mean time for each patient on the round could be calculated.

RELEVANCE TO CLINICAL PRACTICE

Recommendations for vital signs observations need to consider the workload involved and include consideration of the potential opportunity costs if observations are given higher priority at the expense of other aspects of nursing work. Vital signs observations are considered to be a fundamental aspect of nursing work, and key to ensure early detection of patient deterioration. The lack of robust evidence means that those making clinical and managerial decisions about resource allocations, including workload planning around vital signs observations, must make these in the face of considerable uncertainty. Uncertainty means that the workload associated with changes to the frequency of observations associated with early warning scores are unknown. At a system level, the costs from

changes in policy such as the shift from NEWS to NEWS2, which increased the frequency of observations for some patient groups, is unquantifiable. On a ward level, the feasibility of implementing such changes and integrating them into existing work is uncertain. On another hand, workload reductions associated with the introduction of technology that facilitates continuous monitoring, which might reduce requirement for nurses to take vital signs observations, are equally uncertain. Measuring patients' vital signs at times that are appropriate is key to avoiding patient deterioration and adverse outcomes. In the interest of patient safety, further research that uses vital signs and patient objective data aiming to define the optimal frequency of vital signs observations should be conducted.

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WHAT DOES THIS PAPER CONTRIBUTE TO THE WIDER GLOBAL CLINICAL COMMUNITY?

- Time taken to perform vital signs observation activities varied considerably across studies, although most time estimates demonstrate the potential for vital signs to occupy a considerable amount of nursing time, especially if undertaken with high frequency
- There is lack of evidence around the time taken to perform vital signs activities, and this prevents us from informing workload planning around vital signs observations for nurses
- Changes to vital signs observation protocols have an unquantified effect on nurses' workload that could be considerable, making such changes unfeasible..

TABLES

Table 1 Summary of selected studies (N= 16)

Author(s), Year, & Country	Study Design	Sample size & Setting	Vital signs measuring and recording	Data Collection	Results	Vital signs definition
Studies reporting mean times of vital signs measurements and/or recording						
Bellomo et al., 2012 US, Sweden, UK, The Netherlands & Australia	Before-and-after controlled trial	10 hospitals in five countries, 74 nurses. The number of observation hours is unspecified.	**Measurement:** Enhanced surveillance system: manual **Mode of recording and documentation timing:** Enhanced surveillance system: Nurse obtain oxygen saturations, heart rate, blood pressure, temperature and these are automatically transferred and displayed by direct physical link with the monitoring devices. Respiration rate and conscious state are input by the nurse. **Calculation of Early Warning Score (EWS) value**:	Information on how vital signs data were collected before the introduction of the automated advisory vital signs monitors was not reported.	After the introduction of continuous monitoring, time required to complete and record a set of vital signs decreased from on average 4.1 minutes (SD 1.3) to 2.5 minutes (SD 0.5) (difference 1.6; 95% CI: 1.4–1.8; p < .0001)	Temperature, heart rate, respiration rate, blood pressure, oxygen saturations, consciousness, urine output

Author(s), Year, & Country	Study Design	Sample size & Setting	Vital signs measuring and recording	Data Collection	Results	Vital signs definition
			The electronic automated advisory vital signs system automatically calculates EWS. When EWS is calculated, it displays a colour coded message to the nurse (red range prompted the need for increased frequency of monitoring or escalation; safe range in white; observe range in yellow; warning range in orange).			
Clarke, 2006 US	Descriptive observational study	200 patients, 1 community hospital, 1 cardiovascular unit. A total of 10,645 nursing	**Measurement:** Not specified **Mode of recording and documentation timing:** Not specified **Calculation of EWS value**: Not specified	Nurses were asked to self-report the number of times the NIC intervention was used during the shift, estimate	Vital signs monitoring occurred in 814 occasions during the one-month data collection period. Mean time for vital signs monitoring: 5.8	According to NIC definition: "Collection and analysis of cardiovascular, respiratory,

Author(s), Year, & Country	Study Design	Sample size & Setting	Vital signs measuring and recording	Data Collection	Results	Vital signs definition
		intervention (classified with Nursing Intervention Classifications (NIC)) were reported during a one-month data collection period.		the average time each intervention took to complete, and identify the education level that was required to accomplish each intervention.	minutes (SD: 3.72; 95% CI: 5.54-6.06).	and body temperature data to determine and prevent complications ”
Ito et al., 1997 Japan	Before-and-after study with time-motion methodology	1 hospital, 1 Radiology ward, 23 nurses working day shifts	**Measurement:** Mixture of automatic and manual **Mode of recording and documentation timing:** Nurses enter vital signs into the hand held computer at the bed-side. Vital signs data are then	Nurses had to note the time taken to complete vital signs with each patient and calculate total time spent on	Mean time required to measure vital signs and fill in vital signs documentation was reduced from 2.02 minutes to 0.90 minutes ($p<0.01$), because information	Not specified

Author(s), Year, & Country	Study Design	Sample size & Setting	Vital signs measuring and recording	Data Collection	Results	Vital signs definition
			transferred from the hand-held computers to the desktop computers with a cable. The information is then sent automatically to the data server **Calculation of EWS value**: Not specified	each task. This was done before and after introduction of handheld computers for use by bedside	transfer directly from hand-held computers to the desktop computer eliminated the need to duplicate data entry.	
Kimura et al., 2016 Japan [abstract]	Descriptive observational study	One hospital	**Measurement:** Automatic: the radio-frequency identification (RFID) reader on the patient automatically transfers data to the electronic medical records. **Mode of recording and documentation timing:** Automatic: the RFID reader on the patient automatically transfers data to the electronic medical records. **Calculation of EWS value:**	There were no details on how the time required to obtain a set of vital signs was captured.	Time for information to be transferred from the patient tags to the device: Cart: 1.47 minutes (SD: 0.55) per person Bed: 1.27 minutes(SD: 0.62) seconds per person	Body temperature, oxygen saturations, heart rate, blood pressure

Author(s), Year, & Country	Study Design	Sample size & Setting	Vital signs measuring and recording	Data Collection	Results	Vital signs definition
			Not specified			
McGrath et al., 2019 US	Before-and-after study	1 Hospital. Enhanced surveillance system trialled in 2 surgical units, 71 beds. Control were 3 medical-surgical units, 61 beds.	**Measurement:** Enhanced surveillance system: Continuous monitoring for oxygen saturations, heart rate, blood pressure, temperature. Respiration rate is calculated by observation Control: a mixture of automatic and manual instruments. **Mode of recording and documentation timing:** Enhanced surveillance system: All vital signs automatically transferred to electronic medical records by pressing a button on patient's monitor Control: Each vital sign entered manually into medical record after collection	One hundred samples of vital signs assessment were collected in the before and after periods of the study units by direct observation of licensed nurse assistants over 12 months. Time to collect vital signs and enter data into the medical record manually	Mean vital signs assessment times were 2.98 minutes before implementation and 2.15 minutes after implementation.	Temperature, heart rate, Respiration rate, blood pressure, oxygen saturations

Author(s), Year, & Country	Study Design	Sample size & Setting	Vital signs measuring and recording	Data Collection	Results	Vital signs definition
			Calculation of EWS value: Not specified	or electronically was measured using an electronic stop watch. Observations were conducted at various times on multiple days.		
Travers and Hill, 1999 US	Observational time-and-motion study	16 nurses, 1 Emergency Department	**Measurement:** Not specified **Mode of recording and documentation timing:** Not specified **Calculation of EWS value**: Not specified	Nurses observed over 10 days. Research assistants performed prospective, direct observations of triage, using	Mean time of vital signs taken at triage: 4 minutes (range 1.9 – 11.1)	Blood pressure, pulse, respiratory rate, and tympanic temperature

Author(s), Year, & Country	Study Design	Sample size & Setting	Vital signs measuring and recording	Data Collection	Results	Vital signs definition
				stop watches to measure triage start and stop times.		
Wager et al., 2010 US	Observational descriptive	1 hospital, 4 inpatient medical/surgical units, 270 vital signs sets	**Measurement:** Not specified **Mode of recording and documentation timing:** (1) a paper medical record system where vital signs were handwritten on a piece of paper and then transcribed to the patient's record (paper to paper) (2) a clinical documentation system with a ''computer on wheels'' workstation outside the patient's room where vital signs	Observers record the date and time the vital signs were taken and the time the vital signs were entered into the patient's record	Mean time difference between the time vital signs were taken and when the data were recorded in the patient's record: 1) With paper records: mean time: 1.24 minutes (SD: 2.17 minutes) 2) Computer on wheels: 9.15	Blood pressure, temperature, heart rate, SpO2, and respiration rate

Author(s), Year, & Country	Study Design	Sample size & Setting	Vital signs measuring and recording	Data Collection	Results	Vital signs definition
			were handwritten on a piece of paper and then transcribed into a computer on wheels (paper to computer) (3) a clinical documentation system with a tablet PC affixed to the vital signs monitor, a machine where vital signs were immediately transcribed from the vital signs monitor to the tablet PC (machine to computer) **Calculation of EWS value**: Not specified		minutes (SD 7:25 minutes) 3) Tablet PC: mean time: 35 seconds (SD 1:42 minutes)	
Wong et al., 2017 UK	Before-and-after study	606 sets of vital signs observed. 2 university teaching hospitals, 3 medical	**Measurement;** Mixture of manual and automatic **Mode of recording and documentation timing:** Before e-Obs (i.e. a system that allows vital signs to recorded on	Nursing staff were observed. Observers recorded start and end times of: 1) View chart	1) Mean time to view chart: 0.3 minutes (on paper: 0.21 minutes on e-Obs 2) Mean time to	Temperature, heart rate, respiration rate, blood pressure, oxygen saturations,

Author(s), Year, & Country	Study Design	Sample size & Setting	Vital signs measuring and recording	Data Collection	Results	Vital signs definition
		wards.	a handheld device) system was introduced: notes After e-Obs system was introduced: vital signs are manually entered using the tablet **Calculation of EWS value:** Before e-Obs: not specified After e-Obs: Automatic on electronic chart	(locating & opening chart) 2) Take vital signs (measuring & documenting vital signs). Interruptions were timed and subtracted from the measured process duration.	take a complete set of vital signs: 3.58 minutes (SD 8.9) on paper; 2.50 minutes (SD: 0.74) on e-Obs.	oxygen therapy, consciousnes s
Zeitz et al., 2005 Australia	Descriptive observation al study	282 hours of observation, 81 patients, 2 hospitals, 2 surgical units	**Measurement:** Not specified **Mode of recording and documentation timing:** Not specified **Calculation of EWS value:** Not specified	Non-participant observation of nursing practice: observation of post- operative patients in the first 24 hours	Mean time to take vital signs and any other activities alongside was 5.8 minutes (SD: 2.56; range: 1-15)	Temperature, heart rate, respiration rate, blood pressure

Author(s), Year, & Country	Study Design	Sample size & Setting	Vital signs measuring and recording	Data Collection	Results	Vital signs definition
				after returning to the ward over an 8-week period.		
Zeitz et al., 2006 Australia	Descriptive observational study	282 hours of observation, 81 patients, 2 hospitals, 2 surgical units	**Measurement:** Not specified **Mode of recording and documentation timing:** Not specified **Calculation of EWS value:** Not specified	Non-participant observation of nursing practice: observation of post- operative patients in the first 24 hours after returning to the ward over an 8-week period.	Mean time to take vital signs and any other activities alongside was 5.8 minutes (SD: 2.56; range: 1-15)	Temperature, heart rate, respiration rate, blood pressure
Studies which do not provide mean time measurements estimates						
Adomat and Hicks, 2003 UK	Descriptive observational study	360 hours of observation. 1 hospital, 2 Intensive	**Measurement:** Not specified **Mode of recording and documentation timing:**	Video recorder documented nurse activity for 48 continuous	Charting observations/record keeping. 1) ICU A	Not specified

Author(s), Year, & Country	Study Design	Sample size & Setting	Vital signs measuring and recording	Data Collection	Results	Vital signs definition
		Care Units (ICU)	Not specified **Calculation of EWS value:** Not specified	shifts.	High Dependency Unit (HDU) patients: 10.78 min/hour ICU patients: 17.43 min/hour 2) ICU B HDU patients: 5.44 min/hour; ICUpatients:10.66 min/hour	
Erb and Coble, 1989 US	Pilot study	1 general hospital, 1 Trauma Unit with 31 beds; 1 Cardiac Catheter Unit with 26 beds.	**Measurement:** Mixture of automatic and manual **Mode of recording and documentation timing:** The nurse records all vital signs at the bedside unit, which is a system that records blood pressure, pulse rate and	There were no details on how the time required to obtain a set of vital signs was captured other than to say the results came	On average, each nurse saved 11.86 minutes per shift by using the automated system to record vital signs (length of shift was unspecified). This equated to a 63%	Blood pressure, arterial pulse rate, respiration, temperature, intake/output and patient's weight.

Author(s), Year, & Country	Study Design	Sample size & Setting	Vital signs measuring and recording	Data Collection	Results	Vital signs definition
			thermometer. Vital signs data are stored on the nurse station unit, which is a computer at the nurses' station. The bedside unit and nurse station unit are connected by existing telephone wires. **Calculation of EWS value:** Not specified	from a management study of nursing activities.	decrease in overall nursing time on vital signs collection.	
Fuller et al., 2018 US	Before-and-after study	A 32-bed medical telemetry unit with 54 nurses and Unlicensed assistive personnel.	**Measurement:** Mixture of automatic and manual **Mode of recording and documentation timing:** Nurses enter vital signs into the mobile machines directly at the bedside. Vital signs are automatically transferred to electronic health record (real time).	A time and motion study plotted the number of steps and time taken to document vital signs data.	Time to document vital signs before the introduction of mobile vital signs machines interfaced with the electronic health record: 7 min/10 patients. After the introduction it was 0 seconds.	Blood Pressure, heart rate, respirations, temperature, and oxygen saturation

Author(s), Year, & Country	Study Design	Sample size & Setting	Vital signs measuring and recording	Data Collection	Results	Vital signs definition
			Calculation of EWS value: Not specified			
Hendrich et al., 2008 US	Descriptive observational study	382 nurses over 1083 shifts, within 17 health care systems in 15 states, 36 medical-surgical units.	**Measurement:** Not specified **Mode of recording and documentation timing:** Not specified **Calculation of EWS value**: Not specified	Data were collected for 7 consecutive 24-hour days using time-motion methodology. Nurses self-reported what they were doing by recording the activity in which they were engaged when a pager vibrated during the shift. Vital signs was a categorised activity.	Assessments and vital signs observations took on average 30.9 minutes (7.2%) in a 10-hour shift.	Not specified

Author(s), Year, & Country	Study Design	Sample size & Setting	Vital signs measuring and recording	Data Collection	Results	Vital signs definition
Hoi et al., 2010 Singapore	Descriptive observational study	1596 hours of observation. 1 acute care hospital, 19 general wards.	**Measurement:** Mixture of manual and automatic **Mode of recording and documentation timing:** Not specified **Calculation of EWS value:** Not specified	All nursing staff were observed adopting a work sampling technique. Each staff member was coded using a coloured lanyard, activities performed were observed and documented at 5 min intervals.	Observation and monitoring (i.e. vital signs and other assessments including urinary catheter care): 1) 16.5 minutes for very low acuity & dependency patients 2) 40.5 minutes for very high acuity & dependency patients per day	Not specified
Yeung et al., 2012 Canada	Descriptive observational study	44.5 hours of observations, 24 nurses, 88 patients, 3 tertiary care hospitals, 5	**Measurement:** Not specified **Mode of recording and documentation timing:** Two hospitals: pen and paper, some directly on charts before	Nurses were observed. Time-motion methodology to measure the duration of and	1) Measuring vital signs: 12 minutes per nurse over 44.5 hours for measuring vital	Temperature, heart rate, respiration rate, blood pressure, oxygen

Author(s), Year, & Country	Study Design	Sample size & Setting	Vital signs measuring and recording	Data Collection	Results	Vital signs definition
		general medical wards	leaving the bedside One hospital: pen and paper, transcribed on electronic documentation after leaving bedside **Calculation of EWS value:** Not specified	the time between clinical activities i.e. vital signs assessment & documentation.	signs. 2) Total mean documentation time at the electronic documentation based hospital: 53.2 minutes (SD 27.1) 3) Total mean documentation time at the paper only based hospitals: 17.2 minutes (SD 13.2 minutes) over 44.5 hours.	saturations

Table 2 Quality appraisal of studies

Study	Random or representative sample from defined population?	Clear inclusion / exclusion criteria?	Clear description of methods of assessment (time)?	Clear description of what was included / excluded in vital signs?	Was the assessment reliable?	Was information given to determine the precision of the estimate?
Bellomo et al 2012	U	N	N	Y	U	Y
Clarke 2006	N	?N	Y	Y	U	Y
Ito et al 1997	N	N	Y	N	U	N
Kimura et al 2016	N	N	N	Y	U	Y
McGrath et al 2019	N	N	Y	Y	U	N
Travers & Hill 1999	Y	Y	Y	Y	U	N
Wager et al	U	N	N	Y	U	Y

2010						
Wong et al 2017	U	N	Y	Y	U	Y
Zeitz et al 2005	U	N	N	Y	U	Y
Zeitz et al 2006	U	N	N	Y	U	Y
Adomat & Hicks 2003	N	N	Y	N	U	N
Erb & Coble 1989	N	N	N	Y	U	N
Fuller et al 2018	N	N	N	Y	U	N
Hendrich et al 2008	Y	Y	Y	N	U	N
Hoi et al 2010	Y	Y	Y	N	U	N

Yeung et al 2012	U	Y	Y	Y	U	Y

Possible responses are U = Unclear; Y= Yes; N = No

Table 3 Summary of mean time in minutes taken by nursing staff to measure and record vital signs

Study	Mean (Minutes)	Standard Deviation	Vital Signs included	Vital signs activities assessed
Studies involving taking and documenting vital signs				
Bellomo et al., 2012	4.10	1.3	Temperature, heart rate, respiration rate, blood pressure, oxygen saturations, consciousness, urine output	Measure vital signs & document them with paper
Bellomo et al., 2012	2.50	0.5	Temperature, heart rate, respiration rate, blood pressure, oxygen saturations, consciousness, urine output	Measure vital signs & document them electronically at bedside
Clarke, 2006	5.80	3.72	Cardiovascular, respiratory, and body temperature data	Measure vital signs & document them with paper
McGrath et al., 2019	2.15	Not reported	Temperature, heart rate, respiration rate, blood pressure, oxygen saturations	Continuous monitoring (multiple monitors) & document vital signs electronically at bedside
McGrath et al., 2019	2.98	Not reported	Temperature, heart rate, respiration rate, blood pressure, oxygen saturations	Continuous monitoring (single monitor) & document vital signs electronically outside bed space
Travers and Hill, 1999	4	Not reported	Blood pressure, pulse, respiratory rate, and tympanic temperature	Measure vital signs observations
Wong et al.,	3.58	8.9*	Temperature, heart	Measure vital signs &

2017			rate, respiration rate, blood pressure, oxygen saturations, oxygen therapy, consciousness	document them with paper
Wong et al., 2017	2.50	0.74*	Temperature, heart rate, respiration rate, blood pressure, oxygen saturations, oxygen therapy, consciousness	Measure vital signs and document them electronically at bedside
Zeitz, 2005	5.80	2.56	Temperature, heart rate, respiration rate, blood pressure	Measure vital signs & document them with paper
Zeitz, 2006	5.80	2.56	Temperature, heart rate, respiration rate, blood pressure	Measure vital signs & document them with paper
Studies reporting documentation only				
Ito et al., 1997	0.90	Not reported	Not specified	Document vital signs electronically at bedside using RFID from continuous monitor
Ito et al., 1997	2.02	Not reported	Not specified	Document vital signs electronically outside bed space
Kimura et al., 2016	1.27	0.55	Body temperature, oxygen saturations, heart rate, blood pressure	Document vital signs electronically at bedside with hand held device
Kimura et al., 2016	1.47	0.62	Body temperature, oxygen saturations, heart rate, blood pressure	Document vital signs electronically outside bed space
Wager et al, 2010	1.24	2.17	Blood pressure, temperature, heart rate, SpO2, and respiration rate	Mean time difference between the time vital signs were taken and when

				the data were recorded on paper in the patient's record (paper to paper)
Wager et al, 2010	9.15	7.25	Blood pressure, temperature, heart rate, SpO2, and respiration rate	Mean time difference between the time vital signs were taken on paper and when the data were recorded on a computer on wheels
Wager et al, 2010	0.59	1.42	Blood pressure, temperature, heart rate, SpO2, and respiration rate	Mean time difference between the time vital signs were taken on a vital signs monitor and when the data were recorded on PC tablet

*Standard Deviation estimated from 95% CIs

FIGURE LEGENDS

Figure 1 Processes involved with undertaking vital signs

Figure 2 Studies selection process