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SCOPING REVIEW

Importance of specific vital signs in nurses' recognition and response to deteriorating patients: A scoping review

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Abstract

Aim(s): To explore the published research related to nurses' documentation and use of vital signs in recognising and responding to deteriorating patients.

Design: Scoping review of international, peer-reviewed research studies.

Data Sources: Cumulative Index to Nursing and Allied Health Literature Complete, Medline Complete, American Psychological Association PsycInfo and Excerpta Medica were searched on 25 July 2023.

Reporting Method: Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for scoping reviews.

Results: Of 3880 potentially eligible publications, 32 were included. There were 26 studies of nurses' vital sign documentation: 21 adults and five paediatric. The most and least frequently documented vital signs were blood pressure and respiratory rate respectively. Seven studies focused on vital signs and rapid response activation or afferent limb failure. Five studies of vital signs used to trigger the rapid response system showed heart rate was the most frequent and respiratory rate and conscious state were the least frequent. Heart rate was least likely and oxygen saturation was most likely to be associated with afferent limb failure (n = 4 studies).

Conclusion: Despite high reliance on using vital signs to recognise clinical deterioration and activate a response to deteriorating patients in hospital settings, nurses' documentation of vital signs and use of vital signs to activate rapid response systems is poorly understood. There were 21studies of nurses' vital sign documentation in adult patients and five studies related to children.

Implications for the profession and/or patient care: A deeper understanding of nurses' decisions to assess (or not assess) specific vital signs, analysis of the value or importance nurses place (or not) on specific vital sign parameters is warranted. The influence of patient characteristics (such as age) or the clinical practice setting, and the impact of nurses' workflows of vital sign assessment warrants further investigation.

Patient or Public Contribution: No Patient or Public Contribution.

KEYWORDS
clinical deterioration, nursing, nursing assessment, rapid response system, vital signs

1 | INTRODUCTION

Recognising and responding to clinical deterioration is a global patient safety priority. To facilitate recognition of deteriorating patients, escalation of care, and management of deteriorating patients at the point of care, many hospitals around the world have implemented rapid response systems (RRSs) (Hillman et al., 2014). The four major components of a RRS are: the afferent limb to detect clinical deterioration, an efferent response limb, patient safety and quality improvement and governance and administration (Jones et al., 2011). The afferent RRS limb includes predefined vital sign criteria or clinical concern (Jones et al., 2011). Rapid response system afferent limb failure is defined as no documented RRS call despite the patient fulfilling RRS calling criteria (Tirkkonen et al., 2020). Given nurses are the clinicians who most commonly have responsibility for vital sign assessment, the success of hospital RRSs is highly dependent on the accuracy of nurses' patient assessment, data interpretation and escalation of care when deterioration is identified (Chua et al., 2019; Considine & Currey, 2015; Padilla et al., 2018).

The definition of vital signs varies between studies (Dall'ora, Griffiths, Hope, Barker, & Smith, 2020) The vital signs most commonly reported in the literature are respiratory rate, oxygen saturation, heart rate, blood pressure, temperature and level of consciousness (Dall'ora et al., 2020). Similarly, the definition of a 'complete' set of vital signs also varies (Dall'ora et al., 2020). For example, in Australia and the United Kingdom, a complete set of vital signs comprises respiratory rate, oxygen saturation, heart rate, blood pressure, temperature and level of consciousness (Australian Commission on Safety and Quality in Health Care (ACSQHC), 2021; Royal College of Physicians, 2017). In hospitals, vital signs are the most commonly collected patient data and are essential in recognising clinical deterioration; however, there is evidence that vital signs are not documented regularly or accurately (Kellett & Sebat, 2017). Studies of vital sign documentation have typically classified documentation as complete or incomplete (Bleyer et al., 2011; Considine, Hutchinson, et al., 2023) and show variability in the frequency with which specific vital signs are documented. The proportion of assessments of 'sets of vital signs' with one or more missing vital sign are reported to range from zero to 41% (Bleyer et al., 2011;Cahill et al., 2011; Chen et al., 2009; Van Leuvan & Mitchell, 2008). Studies conducted

Impact (Addressing)

What problem did this study address?

This scoping review sought to explore the published research related to nurses' documentation and use of vital signs in recognising and responding to deteriorating patients.

What were the main findings?

Cardiovascular parameters (heart rate and blood pressure) were more commonly documented and used to trigger rapid response systems than respiratory parameters (respiratory rate and oxygen saturation). Despite the important role of nurses in vital sign assessment, interpretation, synthesis, documentation and escalation of care, nurses' documentation of vital signs and use of vital signs to activate rapid response systems is poorly understood.

Where and on whom will the research have an impact?

Nurses with the responsibility of assessing patients' vital signs, and staff overseeing the governance and quality improvement arms of rapid response systems, can use these findings to benchmark their own roles and organisational performance to improve patient safety.

What does this paper contribute to the wider global clinical community?

Blood pressure was the most frequently documented vital sign and respiratory rate was the least frequently documented vital sign, despite respiratory rate being the most sensitive and specific indicator of clinical deterioration. Hypotension and bradycardia were the most common triggers for rapid response system activation and bradypnoea and hypoxaemia were the least common rapid response system triggers. The results of this scoping review suggest that cardiovascular parameters (heart rate and blood pressure) were more commonly documented and used to trigger rapid response system than respiratory parameters (respiratory rate and oxygen saturation). Despite the important role of nurses in vital sign assessment, interpretation, synthesis, documentation and escalation of care, nurses' documentation of vital signs and use of vital signs to activate rapid response systems is poorly understood

over a decade ago showed respiratory rate (Cahill et al., 2011; Chen et al., 2009; Van Leuvan & Mitchell, 2008) and temperature (Bleyer et al., 2011) were the vital signs most frequently reported as missing. Results of a contemporary study show a practice change with temperature (Bleyer et al., 2011; Considine, Hutchinson, et al., 2023) and conscious state (Considine, Hutchinson, et al., 2023) now being the most frequently reported missing vital signs.

Research related to escalation of care for patients with vital sign abnormalities have largely focussed on RRS activation (Considine, Hutchinson, et al., 2023; Flabouris et al., 2015). Rapid response system afferent limb failure (no documented evidence of an RRS activation) occurs in 43%–100% of patients with RRS triggers (Considine, Berry, et al., 2023). There is variation in the vital sign abnormalities used to activate RRS and the vital sign abnormalities most commonly associated with RRS afferent limb failure. For example, blood pressure derangements, tachycardia, tachypnoea, altered conscious state and hyperthermia have been associated with higher likelihood of RRS activation (Considine, Hutchinson, et al., 2023; Davies et al., 2014; Flabouris et al., 2015) and bradycardia, decreased conscious state and hypothermia are significantly less likely to result in RRS activation (Considine, Hutchinson, et al., 2023; Flabouris et al., 2015). The reason why some vital signs are more or less likely to result in RRS activations is unclear. Given that nurses are the most likely clinicians to initiate an RRS call, one possible explanation is that nurses place different levels of importance on specific vital signs as indicators of clinical deterioration.

1.1 | Aim

The aim of this scoping review was to explore the published research related to nurses' documentation and use of vital signs in recognising and responding to deteriorating patients. The specific objectives were to assess the published research related to the specific vital signs most and least: (i) frequently documented, (ii) used to trigger RRS; and (iii) associated with RRS afferent limb failure. Rapid response system afferent limb failure is defined as no documented RRS call despite documented RRS triggers (Tirkkonen et al., 2020). The PICOST framework (population, intervention, comparator, outcomes, studies, and time) was used to inform this scoping review (Table 1).

2 | METHODS

This scoping review was conducted according to the methodological framework developed by Arksey and O'Malley (2005) (defining the research question/s, identifying relevant studies, study selection, charting the data, collating, summarising and reporting the results) and reported using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extensions for Scoping Reviews (PRISMA-ScR) (Tricco et al., 2018) (File S1). The synthesis approach was guided by Synthesis Without Meta-Analysis (SWiM) reporting guidelines and a narrative synthesis method (Campbell et al., 2020).

2.1 | Eligibility criteria

Studies were included if they were primary research studies, published in English, related to nurses' documentation of vital signs or nurses' use of vital signs for RRS activation (or failure to activate) in an acute care hospital setting governed by organisational or local RRS. System or score development or validation studies, studies that involve RRS with criteria requiring pathology test results, studies focused on clinician or nurse concern without vital sign data and studies of neonates were excluded. Editorials, theses, letters, commentaries, opinion papers, case studies, case reports and conference abstracts were also excluded. The inclusion

TABLE 1 PICOST framework.

Population	Nurses working in clinical areas governed by an organisational RRS (e.g., wards—adult and paediatric), or local RRS (e.g., emergency departments)
Intervention	Vital signs: respiratory rate, oxygen saturation, heart rate, blood pressure, temperature, conscious state
Comparator	N/A
Outcome	Recognition of deteriorating patients: documentation of one of more vital sign parameters and recognition of documented RRS triggers
	Response to deteriorating patients: activation of appropriate RRS tier when documented RRS triggers are present
Studies of	Actual or hypothetical vital sign use by nurses Completion of vital sign documentation: which parameters are most or least frequently documented Vital signs triggers for RRS activation: which parameters are most common triggers, which parameters are more or less associated with RRS afferent limb failure
Timing	No time limiters

and exclusion criteria and associated definitions are presented in Table 2.

2.2 | Information sources and search strategy

The following databases were searched on 25 July 2023: Cumulative Index to Nursing and Allied Health Literature (CINAHL) Complete, Medline Complete, APA PsycInfo and EMBASE (Excerpta Medica). No restrictions were placed on publication date and each database was searched from inception. The search strategies for each database are shown in Appendix A1. Forward (searching for articles that cite included studies) and backward (search of reference lists of included studies) citation searching was also conducted.

2.3 | Selection of sources of evidence

EndNote 20.0 was used to identify and remove duplicates. Two researchers independently conducted title and abstract (PC, OO, NVG, JC) and full text screening (PC, JC, NVG) using the Covidence™ software program. Disagreements were resolved by discussion and consensus.

2.4 | Data charting process

Data were charted by two researchers (PC and NVG) and ratified by all co-authors. The characteristics of each study charted included the author(s), year of publication, country, aim, study design, setting, sample and main findings.

2.5 | Synthesis of results

Given the variation in study design, settings, samples and outcomes, the approach to synthesis was guided by the Synthesis Without Meta-Analysis (SWiM) reporting guidelines and narrative synthesis methods (Popay et al., 2006).

3 | RESULTS

3.1 | Selection of sources of evidence

After removing duplicates, our search returned 3880 publications and one additional publication identified through hand searching. In total, 198 full-text publications (197 from databases and one from citation searching) were screened for eligibility, of which 32 were included (Figure 1).

3.2 | Characteristics of sources of evidence

Characteristics of included studies are detailed in (Tables S1, S2 and S3). The majority of studies were from Australia ($n=9$) (Cardona-Morrell et al., 2016; Considine et al., 2016; Considine et al., 2017; Considine et al., 2020; Considine, Berry, et al., 2023; Endacott et al., 2007; Flabouris et al., 2015; Guinane et al., 2013; McGain et al., 2008); United Kingdom ($n=4$) (Alcock et al., 2002; Bird et al., 2009; Gordon & Beckett, 2011; Odell, 2015; Oliva, 2010) and the United States of America ($n=4$) (Derby et al., 2017; Sobie et al., 2000; Still et al., 2018; Tarver & Stuenkel, 2016).

TABLE 2 Inclusion and exclusion criteria.

Term	Inclusion	Exclusion
Nurse	Registered or second level nurses (including but not limited to enrolled nurses, licenced practical nurses, practical nurses) who are registered with a nursing regulatory authority	Studies of non-nurses including but not limited to health care assistants, patient care attendants, physician assistants, emergency medical technicians, nursing students, paramedics
Setting	Acute care hospital setting governed by organisational or local RRS (including but not limited to hospital wards, emergency departments).	Locations other than acute care hospital settings, (including but not limited to subacute care, residential aged care, community care). Acute hospital settings not governed by organisational or local RRS (including but not limited to intensive care units, coronary care units, post-anaesthetic care units).
Vitals signs	Respiratory rate, oxygen saturation, heart rate, blood pressure, temperature, conscious state	Assessment of other objective or subjective patient parameters
Documentation	Paper-based or electronic methods of vital sign documentation	
RRS	Must consist of an afferent limb (specific criteria by which a deteriorating patient is defined) and efferent limb (expected response)	Informal, clinician dependent definitions of clinical deterioration and informal methods of escalating care for deterioration in patients
Afferent limb failure	Presence of RRS triggers and the absence of a documented RRS call	

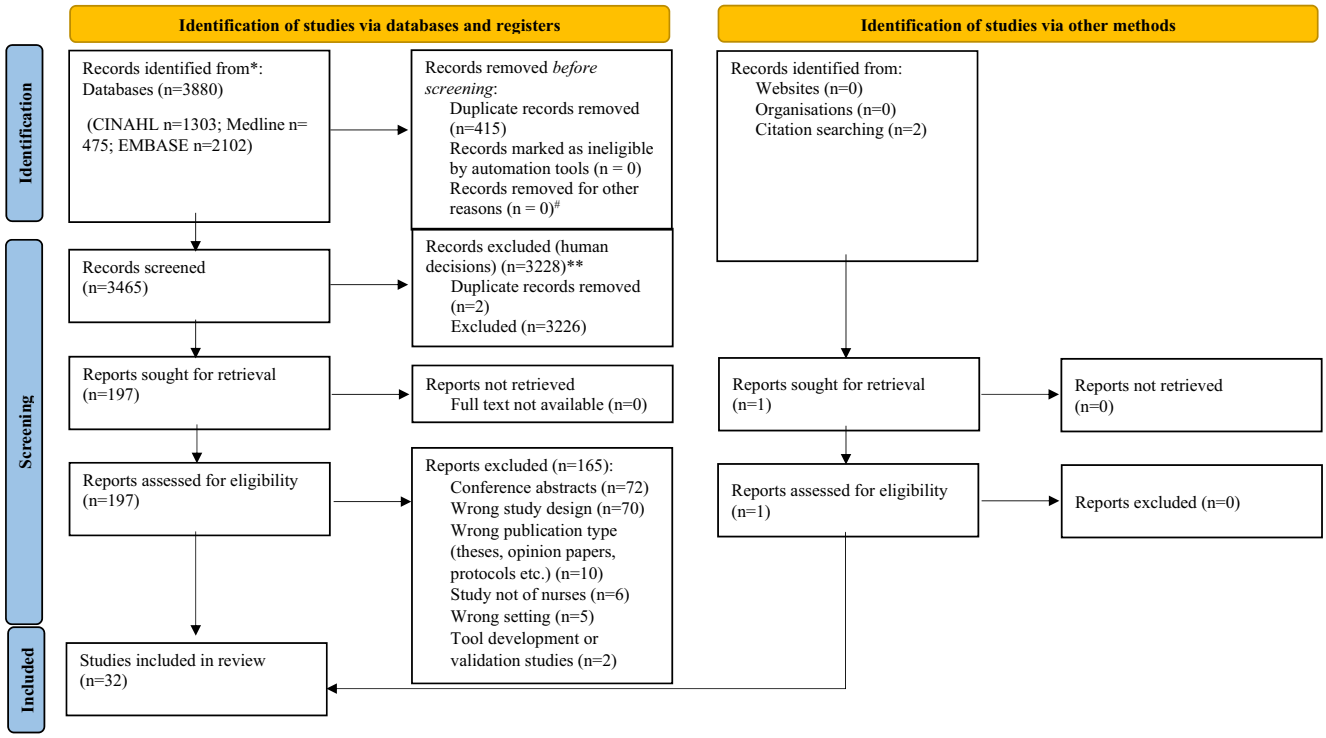

FIGURE 1 PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers and other sources. *Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers). **If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools. From: Page et al. 2021. [Colour figure can be viewed at wileyonlinelibrary.com]

The most common study methods were retrospective cohort ($n=17$) (Alcock et al., 2002; Considine et al., 2016; Eddahchouri et al., 2021; Endacott et al., 2007; Gawronski et al., 2021; Guinane et al., 2013; Jonsson et al., 2011; Keene et al., 2017; Mbabazi & Cassimjee, 2006; McGain et al., 2008; McLaughlin et al., 2021; Odell, 2015; Ogero et al., 2018; Oliva, 2010; Sobie et al., 2000; Stevenson et al., 2016; Tarver & Stuenkel, 2016) and prospective cohort ($n=4$) (Considine et al., 2020; Crandon et al., 2008; Gordon & Beckett, 2011; Still et al., 2018). There were three pre-test/post-test studies (Bird et al., 2009; Derby et al., 2017; Mills et al., 2021), two cross-sectional studies (Cardona-Morrell et al., 2016; De Meester et al., 2013) and two retrospective point prevalence studies (Considine, Berry, et al., 2023; Niegsch et al., 2013). Additionally four single studies used both prospective and retrospective methods (Flabouris et al., 2015), prospective case–control methods (Considine et al., 2017), retrospective case–control methods (Kyriacos et al., 2014) and retrospective longitudinal methods (Juvé-Udina et al., 2018).

3.3 | Results of individual sources of evidence

There were 26 studies of nurses' vital sign documentation: 21 in adults (Table 3) and five in children (Table 4): see Tables S1 and S2 for detailed data charting. In the studies of adult patients, 10 were focused on the ward context (Cardona-Morrell et al., 2016; Considine et al., 2017; De Meester et al., 2013; Derby et al., 2017; Eddahchouri et al., 2021; Gordon & Beckett, 2011; Keene et al., 2017; Mbabazi & Cassimjee, 2006; McGain et al., 2008; Niegsch et al., 2013) and four were focused on the emergency department (including emergency department to ward interface) or inter-hospital transfer context (Alcock et al., 2002; Considine et al., 2016; Crandon et al., 2008; Sobie et al., 2000). Seven studies were related to nurses' vital sign documentation prior to adverse events: intensive care unit admission (Endacott et al., 2007; Jonsson et al., 2011; McLaughlin et al., 2021): in-hospital cardiac arrest (Juvé-Udina et al., 2018; Odell, 2015; Stevenson et al., 2016): and one prior to in-hospital death (Kyriacos et al., 2014) (Table 3). Five studies were focused on nurses' vital sign documentation in children either in inpatient wards (Gawronski et al., 2021; Mills et al., 2021; Ogero et al., 2018; Oliva, 2010) or the emergency department (Bird et al., 2009) (Table 4).

Seven studies focused on use of vital signs in relation to RRS activation or afferent limb failure (Considine et al., 2016; Considine et al., 2020; Considine, Berry, et al., 2023; Flabouris et al., 2015; Guinane et al., 2013; Still et al., 2018; Tarver & Stuenkel, 2016; Tirkkonen et al., 2020) (Table 5: see Table S3 for detailed data charting). Considine et al. (2016) and Flabouris et al. (2015) examined both RRS activation and afferent limb failure. All except one were of adult patients: the remaining study included adult, paediatric and neonatal patients from inpatient wards or post the anaesthesia care unit (Guinane et al., 2013) (Table 5).

TABLE 3 Most and least frequently documented vital signs in adults ($n=21$).

Author, year, country	Population	Most frequently documented vital sign						Least frequently documented vital sign					
		Respiratory rate	Oxygen saturation	Heart rate	Blood pressure	Conscious state	Temperature	Respiratory rate	Oxygen saturation	Heart rate	Blood pressure	Conscious state	Temperature
Total		2	1	8	10	1	5	8	1	2	0	7	4
Adults—ward patients ($n=10$)													
Subtotal		0	0	2	5	0	4	5	0	2	0	4	0
Eddahchouri et al., 2021 The Netherlands	Patients admitted to general hospital wards of a tertiary referral university medical centre ($n=48{,}864$ patients)				✓			✓					
Keene et al., 2017 South Africa	All trauma patients in the acute care trauma wards ($n=181$)				✓					✓			
Considine et al., 2017 Australia	All patients receiving care in the ED, medical or surgical units, and acute mental inpatient health units.			✓								✓	
Derby et al., 2017 United States	Department of nursing (whole of hospital) (n not reported)						✓			✓			
Cardona-Morrell et al., 2016 Australia	Nurses ($n=42$) of adults on one respiratory (medical) and one neurosurgical ward. 79 observations sessions yielding vital sign activity ($n=229$)				✓			✓					
De Meester et al., 2013 Belgium	Adults >15 years from four surgical wards over a 6-day post-operative period, who did not have a do-not-resuscitate order ($n=4247$).						✓	✓ (post-test)				✓ (pre-test)	
Niegsch, 2013 Denmark	Hospital ward patients (age not specified) ($n=132$)						✓					✓	
Gordon & Beckett, 2011 United Kingdom	Patients (assumed adult) in 18 wards ($n=121$) & Combined Assessment Unit ($n=8$)			✓ (ward)	✓ (ward)			✓ (ward)					
McGain et al., 2008 Australia	Adult post-operative patients ($n=211$)				✓			✓					
Mbabazi & Cassimjee, 2006 Rwanda	Medical or surgical ward patients (age not reported) with LOS>5 days ($n=40$)						✓					✓	
Adults—emergency department (including ward interface), inter-hospital transfer ($n=4$)													
Subtotal		1	0	3	0	0	0	0	1	0	0	1	2
Considine et al., 2016 Australia	660/1980 randomly selected adults admitted via ED to a medical or surgical ward who had emergency call for clinical deterioration within 72 h of arrival on the ward	✓											✓
Crandon et al., 2008 Jamaica	Injured adult patients transferred to a university hospital from other hospitals ($n=122$)			✓					✓				
Alcock et al., 2002 United Kingdom	ED patients (age not reported) ($n=728$)			✓								✓	

(Continues)

TABLE 3 (Continued)

Author, year, country	Population	Most frequently documented vital sign						Least frequently documented vital sign					
		Respiratory rate	Oxygen saturation	Heart rate	Blood pressure	Conscious state	Temperature	Respiratory rate	Oxygen saturation	Heart rate	Blood pressure	Conscious state	Temperature
Sobie et al., 2000 United States of America	Adult ED patients with pneumonia ($n=104$): ED border patients ($n=52$) and patients admitted to inpatient bed ($n=52$)			✓									✓
Adults—prior to intensive care unit admission ($n=3$)													
Subtotal		1	1	1	0	0	0	1	0	0	0	1	1
Endacott et al., 2007 Australia	Ward patients (age not reported) in 24 h prior to unexpected ICU admission ($n=17$ patients)	✓										✓	
Jonsson et al., 2011 Iceland	Patients aged ≥18 years on medical or surgical wards who were emergency admissions to either of two ICUs ($n=65$) in a 3-month period			✓				✓					
McLaughlin et al., 2021 Canada	All adult patients (≥ 18 years of age) diagnosed with acute leukaemia admitted to ICU ($n=7$) versus not admitted to ICU ($n=30$)		✓										✓
Adults—prior to in-hospital cardiac arrest (n=3)													
Subtotal		0	0	2	3	0	0	1	0	0	0	1	1
Odell, 2015 United Kingdom	Adult non-obstetric patients, in medical, surgical or geriatric care wards, who had a cardiac arrest, anytime in a 12-month period ($n=123$)			✓	✓								✓
Stevenson et al., 2016 Sweden	Patients (does not specify adults only) not in the ICU, who suffered an in-hospital cardiac arrest and received cardiopulmonary resuscitation from 2007 to 2011, listed on the Swedish Register for In-hospital Cardiac Arrest ($n=228$)				✓							✓	
Juvé-Udina et al., 2017 Spain	Adult patients who had suffered an in-hospital cardiac arrest without a DNR order ($n=450$)			✓	✓			✓					
Adults—prior to in-hospital death ($n=1$)													
Subtotal		0	0	0	2	1	1	1	0	0	0	0	0
Kyriacos et al., 2014 South Africa	Adults aged >13 years admitted to general, vascular and orthopaedic surgery wards. Cases: unexpected death on the ward within 7 days of surgery with general anaesthesia and had no DNR order ($n=11$) Controls: no death on the ward within 7 days of surgery with general anaesthesia and had no DNR order and remained on the ward until discharge ($n=44$)				✓ (cases) ✓ (control)	✓ (cases)	✓ (cases)	✓					

Abbreviations: DNR, do not resuscitate; ED, emergency department; ICU, intensive care unit; LOS, length of stay; PACU, post anaesthetic care unit; RRT, Rapid Response Team; RRS, Rapid Response system; SD, Standard Deviation.

TABLE 4 Most and least frequently documented vital signs in children ($n = 5$).

Author, year, country	Population	Most frequently documented vital sign						Least frequently documented vital sign					
		Respiratory rate	Oxygen saturation	Heartrate	Blood pressure	Conscious state	Temperature	Respiratory rate	Oxygen saturation	Heart rate	Blood pressure	Conscious state	Temperature
Total		0	0	1	1	1	3	1	0	2	3	0	1
Mills et al., 2021 Palestine	A paediatric haematology and oncology ward (each pre-test sample ranged from $n = 79$ to $n = 230$)						✓	✓		✓			
Gawronski et al., 2021 Italy	Children admitted to hospital wards in a large tertiary care children's hospital ($n = 522$)				✓								✓
Ogero et al., 2018 Kenya	Children admitted with non-surgical conditions at 13 Kenyan county hospitals ($n = 54{,}800$)						✓			✓			
Oliver, 2010 United Kingdom	1000 children ($0 < 16$ years) ($n = 9075$) admitted to wards of a Children's Hospital						✓				✓		
Bird et al., 2009 United Kingdom	Children <6 years ($n = 212$) with severe illness or injury at first assessment in ED triage.			✓							✓		
	Head injury sub-cohort					✓					✓		

Abbreviations: DNR, do not resuscitate; ED, emergency department; ICU, intensive care unit; LOS, length of stay; PACU, post anaesthetic care unit; RRT, rapid response Team; RRS, rapid response system; SD, Standard Deviation.

TABLE 5 Most and least frequent rapid response system triggers ($n=7$*).

Author, year, country	Population	Respiratory rate	Oxygen saturation	Heart rate	Blood pressure	Conscious state	Temperature	Respiratory rate	Oxygen saturation	Heart rate	Blood pressure	Conscious state	Temperature
		Most frequent RRS system trigger						Least frequent RRS trigger					
Total		1	0	3	2	1	0	2	1	1	1	2	0
Considine et al., 2020 Australia	Patients in acute care transferred to inpatient rehabilitation or geriatric evaluation and management ($n=1763$ patients, $n=244$ RRS calls)				✓ (↓)			✓ (↓)					
Still et al., 2018 United States of America	Patients with MET activation without DNR order and remained on ward ($n=471$ patients)				✓(–)							✓ (↓)	
Considine et al., 2016 Australia	Adults admitted via ED to a medical or surgical ward who had emergency call for clinical deterioration within 72 h ($n=660$)												
	• First 4 h of admission	✓ (↑)								✓ (↑)			
	• 4.1–24 h after admission			✓ (↑)							✓ (↓)		
	• 24–72 h after admission					✓ (↓)		✓ (↑)					
Tarver et al., 2016, United States of America	Adults in medical or surgical units of a single hospital who had a RRT call ($n=135$). ** time to RRS call			✓(–)								✓ (↓)	
Flabouris et al., 2015 Australia	General medical or general surgical adult patients ($n=416$)			✓ (↓)					✓ (↓)				
		Least frequent RRS afferent limb failure						Most frequent RRS afferent limb failure					
Total		1	0	3	0	2	0	0	2	1	1	0	0
Considine et al. in press Australia	Adult inpatients (aged>18 years) with MET afferent limb failure ($n=25$)					✓ (↓)					✓ (↓)		
Considine et al., 2016 Australia	Adults admitted via ED to a medical or surgical ward who had emergency call for clinical deterioration within 72 h ($n=660$)	✓ (↑)								✓ (↓)			
Flabouris et al., 2015 Australia	General medical or general surgical adult patients ($n=416$)			✓ (↓) ✓ (↑)		✓ (↓)			✓ (↓)				
Guinane et al., 2013 Australia	Adult, paediatric and neonatal ward or PACU patients with LOS ≥24 h and discharged within 7 days study period who fulfilled RRS criteria ($n=82$)			✓ (↓)					✓(–)				

Abbreviations: dash, direction of change not reported; ICU, intensive care unit; ° F, degrees Fahrenheit; LOS, length of stay; PACU, post anaesthetic care unit; RRT, Rapid Response Team; RRS, Rapid Response system; SD, Standard Deviation; ↑=increased; ↓=decreased.

*Considine et al. (2016) and Flabouris et al. (2015) span both RRS activation and afferent limb failure.

3.4 | Synthesis of results

The vital sign most frequently documented across the 26 included studies was blood pressure in 10 studies and notably, it was never the least frequently documented vital sign. Respiratory rate was the least frequently documented vital sign in eight studies, followed by conscious state in seven studies. Blood pressure was the most frequently documented vital sign for the majority of adult specific subgroups (adult ward patients, emergency department or transferred patients, patients prior to in-hospital cardiac arrest or death). The least frequently documented vital sign varied across adult subgroups (Table 3) (see Table S1 for detailed data charting). In the five paediatric studies, temperature was the most frequently documented vital sign ($n=3$ studies) and blood pressure was most commonly the least frequently documented vital sign ($n=3$ studies) (Table 4) (see Table S2 for detailed data charting).

There were five studies of specific vital signs used to trigger the RRS (Considine et al., 2016; Considine et al., 2020; Flabouris et al., 2015; Still et al., 2018; Tarver & Stuenkel, 2016) (Table 5) (Table S3 for detailed data charting). Overall, heart rate was the most frequent and respiratory rate and conscious state were the least frequent vital signs used to trigger the RRS (Table 5). There was variability in the time periods examined. The two studies that focused on RRS activation during the entire patient admission reported hypotension (Considine et al., 2020) and bradycardia (Flabouris et al., 2015) as the most common triggers; respiratory issues of bradypnea (Considine et al., 2020) and hypoxaemia (Flabouris et al., 2015) were the least common RRS triggers. Studies of the first 4 h of hospital admission only reported blood pressure (Still et al., 2018) and tachypnoea (Considine et al., 2016) as most common triggers and conscious state (Still et al., 2018) and tachycardia (Considine et al., 2016) as least common RRS triggers. In other specifically reported time periods, the most common RRS triggers were tachycardia 4–24 h after admission and decreased conscious state 24–72 h after admission (Considine et al., 2016); the least common RRS triggers across those time points were hypotension and tachypnoea respectively (Considine et al., 2016). One study looked at time between documentation of RRS trigger and RRS call: tachycardia had the shortest time to RRT call, an acute change in level of consciousness was the longest time to RRT call (Tarver & Stuenkel, 2016) (Table 5).

There were four studies of RRS afferent limb failure (Considine et al., 2016; Considine, Berry, et al., 2023; Flabouris et al., 2015; Guinane et al., 2013) (Table 5) (see Table S3 for detailed data charting). Overall, heart rate was least likely and oxygen saturation was most likely to be associated with RRS afferent limb failure (Table 5). Of the four studies that focussed on RRS afferent limb failure, hypotension (Considine et al., 2016; Considine, Berry, et al., 2023), hypoxaemia (Flabouris et al., 2015) and respiratory rate (Guinane et al., 2013) were the three most common triggers associated with failure to call RRS. The triggers least likely to result in failure to call were highly variable: decreased conscious state (Considine, Berry, et al., 2023; Flabouris et al., 2015), tachypnoea (Considine et al., 2016), bradycardia (Flabouris et al., 2015), tachycardia (Flabouris et al., 2015) and systolic blood pressure (Guinane et al., 2013).

4 | DISCUSSION

4.1 | Summary of evidence

This study had three major findings. First, the most and least frequently documented vital signs were blood pressure and respiratory rate in adults and temperature and blood pressure in children. Second, the vital sign most frequently used to trigger the RRS was heart rate; respiratory rate and conscious state were the least frequent RRS triggers. Finally, heart rate was least likely and oxygen saturation was most likely to be associated RRS afferent limb failure.

In adults, the most frequently documented vital sign was blood pressure and least frequently documented vital sign was respiratory rate. Reasons for the dominant frequency of blood pressure documentation may relate to workflow or clinical emphasis. Using automated non-invasive blood pressure monitoring allows other nursing work to be performed simultaneously. Hypotension, erroneously, has long been considered the first warning and key vital sign of clinical deterioration (Mok, Wang, Cooper, et al., 2015); however, tachypnoea is a more accurate and an earlier indicator of deterioration than hypotension (Churpek et al., 2016; Cretikos et al., 2007). The rate of omission of respiratory rate from vital sign documentation ranges from 0.8%–81.5% (Kallioinen et al., 2021) and a number of studies in a 2019 systematic review on RRS and deteriorating patients report infrequent documentation of respiratory rate (Difonzo, 2019). A 2022 integrative review on nurses' measurement of respiratory rate highlighted issues that included high levels of bias, estimation and incorrect techniques; lack of knowledge and undervaluing the clinical significance of respiratory rate; and a tendency to substitute oxygen saturation for respiratory rate measurement (Palmer et al., 2023). Our findings suggest nurses have are not embedding respiratory rate documentation in practice with sufficient frequency, given that this finding was evident across all adult-based settings and prior to all adverse events.

In children, temperature was the most frequently documented and blood pressure the least frequently documented vital sign. The settings of the five included paediatric studies, may in part, explain the frequency of temperature assessment. For example, one study was situated on a paediatric haematology / oncology ward (Mills et al., 2021) where children are at higher risk of sepsis. Another multihospital study was situated in Kenya (Ogero et al., 2018) which, like many sub-Saharan African countries has high levels of childhood mortality with issues such as respiratory infections, sepsis, malaria and diarrheal disease prominent causes of death in infants and children (Breiman et al., 2021). The reasons for the infrequency of blood pressure measurement is unclear. Possible explanations may include small children's lack of

cooperation with blood pressure measurement and, or the distress that cuff inflation may cause in children.

The second major finding was related to RRS vital sign triggers: heart rate was the most frequent trigger, the least frequent triggers were respiratory rate and conscious state. All included studies were from non-critical care areas with no continuous heart rate monitoring; however, heart rate is readily displayed on most bedside pulse oximeters and so easily accessible to nurses. It may be argued that heart rate is an integral criterion for all RRSs; however, the same can be argued for respiratory rate and conscious state (Winters et al., 2007). It is possible that these findings are a function of frequency and an increased likelihood of detecting an abnormality in more frequently assessed or documented vital signs. The discovery of an unconscious patient on hospital wards is an infrequent event and given respiratory rate was the least frequently documented vital sign in our study, by logic it follows that these vital signs will also be the least used to trigger an RRS.

The relationships between technology, vital sign measurement and documentation may partly explain infrequent documentation of respiratory rate, and low use of respiratory rate and conscious state as RRS triggers. The majority of vital sign related nurse–patient interactions involves the use of technology in the forms of automated monitors (95%) or digital thermometers (87%) (Cardona-Morrell et al., 2016). By contrast respiratory rate is the vital sign most commonly measured without automation (Ansell et al., 2014; Churpek et al., 2018), meaning nurses need to consciously stop and manually count patients' respiratory rates (Kellett, 2017; Van Loon et al., 2015). One study has shown nurses are not consistently performing these manual assessments, with respiratory rates being documented in only 22% of vital sign assessments (Cardona-Morrell et al., 2016). Given the positive predictive value of tachypnoea rate for clinical deterioration (Churpek et al., 2016; Cretikos et al., 2007), nurses' investment of time in manually measuring respiratory rate is unarguably highly rewarding from a cost–benefit perspective for patient safety.

The final major finding was that RRS afferent limb failure was least likely when there was a heart rate RRS trigger and more likely when RRS level hypoxaemia was present. However, vital signs associated with failure to call RRS were highly variable across the included studies. Between 1% and 14% of acute care patients fulfil organisational RRS criteria at a single point in time (Bucknall et al., 2013; Considine, Berry, et al., 2023) and RRS afferent limb failure occurs in 43%–100% of patients with RRS triggers (Considine, Berry, et al., 2023). One possible explanation for this finding is the capacity of nurses to manage vital sign abnormalities within their scope of practice. In fact, adjusting supplemental oxygen is one of the most frequent nursing interventions for patients with RRS triggers, irrespective of whether an RRS activation is made (Considine, Hutchinson, et al., 2023). For example, in the presence of hypoxaemia, it is within nursing scope of practice to initiate or increase supplemental oxygen and reassess oxygen saturation. However, nurses' ability to manage bradycardia or tachycardia are limited as primary heart rate abnormalities often require pharmacological solutions and secondary heart rate abnormalities changes require investigations and medical assessments for targeted therapies.

Critique of the evidence related to of nurses' documentation and use of specific vital sign parameters to activate RRSs has not resulted in a deeper understanding of nurses' documentation and use of vital signs in recognising and responding to deteriorating patients. Vital sign assessment is critical for patient safety and there has been widespread implementation of safety systems dependent on vital sign data to guide escalation of care. Many studies to date have focused on the sensitivity and specificity of vital sign parameters in predicting or detecting clinical deterioration (Brekke et al., 2019; Churpek et al., 2016; Mok, Wang, & Liaw, 2015) or adverse events such as unplanned ICU admission, in-hospital cardiac arrest or mortality (Bleyer et al., 2011; Churpek et al., 2012; Cretikos et al., 2007). It is nurses who are largely responsible for vital sign assessment, interpretation, synthesis and escalation of care. Therefore, research on the importance, value or prioritisation of specific vital sign parameters by nurses is critical to understanding how nurses' recognise and respond to deteriorating patients and make escalation of care decisions.

Assessment of one or more vital signs occurs in 52% of nurse–patient interactions and the measurement (or not) of specific vital signs is a function of nurses' clinical judgement (Cardona-Morrell et al., 2016); yet, how those decisions are made is poorly understood. Factors such as knowledge about vital signs as indicators of deterioration, time constraints, distractions, nurse staffing and time of day have been reported to influence nurses' vital sign assessments (Cardona-Morrell et al., 2016; Mok, Wang, Cooper, et al., 2015). Electronic, automated and continuous vital sign monitoring have been proposed as a patient safety strategy, eliminating nurse's discretion regarding vital sign assessment and RRS activation. However there is no high certainty evidence that continuous vital sign monitoring decreases in-hospital cardiac arrest, unplanned ICU admission, failure to rescue; and, to date, there are no published economic analyses related to this technology (Leenen et al., 2020).

4.2 | Limitations

The strengths of this scoping review are the rigorous and systematic search technique, clear inclusion and exclusion criteria and comprehensive data extraction. The limitations of this scoping review are that studies were limited to publications in English and the significant heterogeneity across studies precluded meta-analysis.

5 | CONCLUSION

There is high reliance on using vital signs to recognise clinical deterioration and activate a response to deteriorating patients in hospital settings. The results of this scoping review suggest that cardiovascular parameters were more commonly documented and used to

trigger RRSs than respiratory parameters. Despite the criticality of nurses to vital sign assessment, interpretation, synthesis, documentation and escalation of care, nurses' documentation of vital signs and use of vital signs to activate RRSs is poorly understood. Further research is required to gain a deeper understanding of nurses' decisions to assess (or not assess) specific vital signs and analysis of the value or importance nurses place (or not) on specific vital sign parameters is required. Further, the influence of patient characteristics (such as age) or the clinical practice setting and the impact of nurses' workflows of vital sign assessment warrants further investigation in future studies.

AUTHOR CONTRIBUTIONS

Julie Considine: Conceptualization, Methodology, Validation, Formal Analysis, Data curation, Writing – original draft, Project administration **Penelope Casey:** Methodology, Validation, Formal Analysis, Data curation, Writing – review & editing, Project administration **Olumuyiwa Omonaiye:** Conceptualization, Methodology, Validation, Formal Analysis, Data curation, Writing – review & editing **Nantanit van Gulik:** Formal Analysis, Data curation, Writing – review & editing **Joshua Allen:** Methodology, Validation, Writing – review & editing, Project administration **Judy Currey:** Methodology, Validation, Formal Analysis, Data curation, Writing – original draft.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare.

DATA AVAILABILITY STATEMENT

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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APPENDIX A

TABLE A1 Search strategy.

Date: 25/07/2023		
Database: CINAHL complete via EBScohost		
Time: Unlimited		
Limiters: Published in English		
S74	S11 AND S45 AND S72 [limit to English]	1303
S73	S11 AND S45 AND S72	1464
S72	S48 OR S54 OR S57 OR S68 OR S71	369,939
S71	S69 OR S70	1790
S70	measur* N5 (vital sign*)	908
S69	monitor* N5 (vital sign*)	990
S68	S58 OR S59 OR S60 OR S61 OR S62 OR S63 OR S64 OR S65 OR S66 OR S67	169,567
S67	TI "electronic medical record*" OR AB "electronic medical record*"	12,132
S66	(MH "Electronic Health Records+")	28,973
S65	TI "Health record*" OR AB "Health record*"	19,440
S64	TI "Healthcare record*"OR AB "Healthcare record*"	351
S63	TI "Health care record*" OR AB "Health care record*"	254
S62	(MH "Nursing Records")	3350
S61	S61 TI "Patient* Record*" OR AB "Patient* Record*"	6818
S60	MH ("Patient Record Systems+")	36,557
S59	TI "medical record*" OR AB "medical record*"	47,826
S58	(MH "Medical Records+")	118,500
S57	S55 OR S56	27
S56	TI "between the flags" OR AB "between the flags"	22
S55	TI "track and trigger chart*" OR AB "track and trigger chart*"	5
S54	S50 OR S51 OR S52 OR S53	668
S53	TI "observational chart*" OR AB "observational chart*"	61
S52	TI "observation chart*" OR AB "observation chart*"	102
S51	TI "observations chart*" OR AB "observations chart*"	9
S50	TI "clinical chart*" OR AB "clinical chart*"	498
S49	TI chart* OR AB chart*	48,188
S48	S46 OR S47	322,947
S47	TI document* OR AB document*	138,940
S46	(MH "Documentation+")	204,681
S45	S16 OR S20 OR S24 OR S29 OR S32 OR S37 OR S44	429,651
S44	S38 OR S39 OR S40 OR S41 OR S42 OR S43	8165
S43	TI "AVPU" OR AB "AVPU"	37
S42	TI "ACDU" OR AB "ACDU"	4
S41	TI "GCS" OR AB "GCS"	3860
S40	TI "Glasgow coma score*" OR AB "Glasgow coma score*"	674
S39	TI "Glasgow coma scale*" OR AB "Glasgow coma scale*"	4310
S38	TI "level* of consciousness" OR AB "level* of consciousness"	1467
S37	S33 OR S34 OR S35 OR S36	50,359
S36	TI "temperature*" OR AB "temperature*"	31,793
S35	(MH "Body Temperature+")	12,315
S34	(MH "Body Temperature Determination")	1524
S33	(MH "Temperature+")	20,989
S32	S30 OR S31	108,450
S31	TI "blood pressure*" OR AB "blood pressure*"	83,571
S30	(MH "Blood Pressure+")	57,576
S29	S25 OR S26 OR S27 OR S28	57,801
S28	TI "pulse rate" OR AB "pulse rate"	1401
S27	(MH "Pulse+")	2768
S26	TI "heart rate" OR AB "heart rate"	37,395
S25	(MH "Heart Rate+")	35,851
S24	S21 OR S22 OR S23	13,840
S23	TI "pulse oximetry *" OR AB "pulse oximetry*"	2971
S22	TI "oxygen saturation*" OR AB "oxygen saturation*"	8948
S21	(MH "Oxygen Saturation")	5290
S20	S17 OR S18 OR S19	5766
S19	TI "breathing rate" OR AB "breathing rate"	171
S18	TI "respiratory rate*" OR AB "respiratory rate*"	4326
S17	(MH "Respiratory Rate")	2421
S16	S12 OR S13 OR S14 OR S15	232,488
S15	TI "physiological observations*" OR AB "physiological observation*"	56
S14	TI observation* OR AB observation*	186,704

TABLE A1 (Continued)

Date: 25/07/2023		
Database: CINAHL complete via EBScohost		
Time: Unlimited		
Limiters: Published in English		
S13	TI vitals OR AB vitals	48,176
S12	TI "vital sign*" OR AB "vital sign*"	8769
S11	S5 AND S10	60,916
S10	S6 OR S7 OR S8 OR S9	313,024
S9	inpatient*	132,422
S8	(MH "Inpatients")	86,723
S7	hospitali*	143,615
S6	(MH "Hospitalisation+")	118,324
S5	S1 OR S2 OR S3 OR S4	1,001,874
S4	"nursing"	773,801
S3	"nurses"	404,275
S2	"nurse"	291,944
S1	(MH "Nurses+")	229,648

Date: 25/07/2023		
Database: MEDLINE complete via EBSCOhost		
Time: Unlimited		
Limiters: Published in English		
69	Limit 69 to (english language and humans)	475
68	11 and 44 and 67	560
67	47 or 51 or 54 or 66	828,429
66	55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 63 or 64 or 65	257,377
65	(measur* adj1 vital*).mp. [mp=title, book title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	546
64	(monitor* adj1 vital*).mp. [mp=title, book title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	473
63	(electronic adj medical adj record*).ti, ab.	24,798
62	Electronic Health Records/	27,071
61	(Health adj record*).ti, ab.	31,495
60	(health adj care adj record*).ti, ab.	475
59	(healthcare adj record*).ti, ab.	730
58	Nursing Records/	6670

TABLE A1 (Continued)

Date: 25/07/2023		
Database: MEDLINE complete via EBSCOhost		
Time: Unlimited		
Limiters: Published in English		
57	(patient adj record*).ti, ab.	15,075
56	(medical adj record*).ti, ab.	139,187
55	Medical Records/	66,290
54	52 or 53	163
53	between the flags.ti, ab.	24
52	(track adj2 trigger).ti, ab.	140
51	48 or 49 or 50	127,191
50	(observation* adj chart*).ti, ab.	294
49	(clinical adj chart*).ti, ab.	2134
48	chart*.ti, ab.	127,191
47	45 or 46	486,398
46	document*.ti, ab.	476,889
45	Documentation/	19,337
44	19 or 23 or 27 or 31 or 34 or 38 or 43	2,254,499
43	39 or 40 or 41 or 42	32,029
42	(ACDU or AVPU).ti, ab.	62
41	GCS. ti, ab.	18,967
40	(Glasgow adj1 Coma adj1 Sc*).ti, ab.	13,899
39	(level adj2 conscious*).ti, ab.	5727
38	35 or 36 or 37	841,121
37	Body Temperature/	49,365
36	Temperature/	263,901
35	Temperature.ti, ab.	707,339
34	32 or 33	478,085
33	Blood Pressure/	291,694
32	(blood adj2 pressure).ti, ab.	332,191
31	28 or 29 or 30	269,361
30	(pulse adj2 rate).ti, ab.	10,201
29	Heart Rate/	175,601
28	(heart adj2 rate).ti, ab.	174,760
27	24 or 25 or 26	37,958
26	(pulse adj2 oximetry).ti, ab.	7697
25	Oxygen Saturation/	651
24	(oxygen adj2 saturation).ti, ab.	33,041
23	20 or 21 or 22	21,706
22	(breathing adj2 rate).ti, ab.	1717
21	Respiratory Rate/	3855
20	(respiratory adj2 rate).ti, ab.	18,193
19	12 or 14 or 15 or 16 or 17 or 18	793,413
18	(observation or observations).ti, ab.	772,853
17	(physiological adj2 observation*).ti, ab.	822

(Continues)

TABLE A1 (Continued)

Date: 25/07/2023		
Database: MEDLINE complete via EBSCOhost		
Time: Unlimited		
Limiters: Published in English		
16	Vital Signs/	2089
15	vitals.ti, ab.	961
14	limit 13 to abstracts	20,161
13	(vital adj2 sign*).mp. [mp = title, book title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	20,813
12	(vital adj2 sign*).m_titl.	2145
11	5 and 10	38,897
10	6 or 7 or 8 or 9	486,608
9	inpatient.mp.	102,139
8	Inpatients/	29,390
7	hospitali*.mp.	406,971
6	Hospitalisation/	135,000
5	1 or 2 or 3 or 4	801,962
4	Nursing Staff, Hospital/	47,969
3	exp Nurses/	98,562
2	(nurse or nurses or nursing).ti, ab.	497,192
1	nurs*.mp.	801,962
Date: 25/07/2023		
Database: EMBASE		
Time: Unlimited		
Limiters: Published in English		
#78	#11 AND #51 AND #76 AND [humans]/lim AND [english]/lim AND [embase]/lim	2102
#77	#11 AND #51 AND #76	2851
#76	#56 OR #60 OR #63 OR #72 OR #75	754,077
#75	#73 OR #74	1167
#74	monitor* NEXT/1 vital*	585
#73	measur* NEXT/1 vital*	587
#72	#64 OR #65 OR #66 OR #67 OR #68 OR #69 OR #70 OR #71	299,764
#71	'electronic health record*':ti, ab	35,753
#70	'electronic health record*':ti, ab	35,753
#69	'health record*':ti, ab	43,199
#68	'healthcare record*':ti, ab	1110
#67	'health care record*':ti, ab	655
#66	'nurs* record*':ti, ab	1492

TABLE A1 (Continued)

Date: 25/07/2023		
Database: EMBASE		
Time: Unlimited		
Limiters: Published in English		
#65	'patient record*':ti, ab	27,151
#64	'medical record*':ti, ab	231,560
#63	#61 OR #62	38
#62	'between the flags':ti, ab	28
#61	'track and trigger chart*':ti, ab	10
#60	#57 OR #58 OR #59	228,186
#59	chart*:ti, ab	228,186
#58	'clinical chart*':ti, ab	3864
#57	'observation* chart*':ti, ab	686
#56	#52 OR #53 OR #54 OR #55	269,871
#55	documentation:ti, ab	92,760
#54	documents:ti, ab	57,695
#53	document:ti, ab	114,631
#52	'medical documentation'/exp	29,470
#51	#19 OR #23 OR #27 OR #32 OR #37 OR #43 OR #50	2,273,055
#50	#44 OR #45 OR #46 OR #47 OR #48 OR #49	49,645
#49	'avpu':ti, ab	112
#48	'acdu':ti, ab	8
#47	'gcs':ti, ab	31,171
#46	'glasgow coma sc*':ti, ab	15,803
#45	'level of conscious*':ti, ab	7039
#44	'consciousness level'/exp	4748
#43	#38 OR #39 OR #40 OR #41 OR #42	81,737
#42	'temperature monitoring':ti, ab	2305
#41	'temperature measurement':ti, ab	2590
#40	'body temperature monitoring'/exp	853
#39	'body temperature measurement'/exp	2493
#38	'body temperature'/exp	75,762
#37	#33 OR #34 OR #35 OR #36	845,041
#36	'blood pressure monitoring':ti, ab	13,047
#35	'blood pressure monitoring'/exp	57,420
#34	'blood pressure*':ti, ab	480,776
#33	'blood pressure'/exp	689,470
#32	#28 OR #29 OR #30 OR #31	407,006
#31	'pulse rate*':ti, ab	12,249
#30	'pulse rate'/exp	47,280
#29	'heart rate*':ti, ab	244,023
#28	'heart rate'/exp	305,249
#27	#24 OR #25 OR #26	96,725
#26	'pulse oximetry':ti, ab	11,142

TABLE A1 (Continued)

Date: 25/07/2023		
Database: EMBASE		
Time: Unlimited		
Limiters: Published in English		
#25	'oxygen saturation*':ti, ab	49,418
#24	'oxygen saturation'/exp	71,747
#23	#20 OR #21 OR #22	63,865
#22	'respiratory rate*':ti, ab	27,574
#21	'breathing rate':ti, ab	1632
#20	'breathing rate'/exp	55,090
#19	#12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18	1,073,079
#18	'clinical monitoring'/exp	635
#17	'patient monitoring'/de	98,940
#16	'patient vital sign monitor'/exp	229
#15	observation: ti, ab OR observations: ti, ab	935,197
#14	'physiological observation*':ti, ab	617
#13	'vital sign*':ti, ab	36,924
#12	'vital sign'/exp	30,636
#11	#5 AND #10	190,393
#10	#6 OR #7 OR #8 OR #9	2,075,790
#9	'hospital patient*':ti, ab	31,889
#8	'hospital patient'/exp	223,059
#7	'inpatient*':ti, ab	245,148
#6	hospital:ti, ab	1,891,037
#5	#1 OR #2 OR #3 OR #4	1,278,717
#4	nursing	1,073,220
#3	nurses	322,185
#2	nurse	421,020
#1	'nurse'/exp	210,491