Revista Brasileira de Enfermagem
REBEn

THEMATIC EDITION
ADVANCED NURSING PRACTICES

REVIEW

Technologies used by nursing to predict clinical deterioration in hospitalized adults: a scoping review

Tecnologias utilizadas pela enfermagem para predição de deterioração clínica em adultos hospitalizados: revisão de escopo

Tecnologías utilizadas por la enfermería para predecir el deterioro clínico en adultos hospitalizados: revisión del alcance

Érica Sobral Gondim[I]
ORCID: 0000-0001-5257-6245

Emiliana Bezerra Gomes[I]
ORCID: 0000-0002-7135-512X

José Hiago Feitosa de Matos[I]
ORCID: 0000-0001-8473-7269

Sarah de Lima Pinto[I]
ORCID: 0000-0002-9020-5610

Célida Juliana de Oliveira[I]
ORCID: 0000-0002-8900-6833

Ana Maria Parente Garcia Alencar[I]
ORCID: 0000-0003-0459-4291

[I] *Universidade Regional do Cariri. Crato, Ceará, Brazil.*

How to cite this article:
Gondim ES, Gomes EB, Matos JHF, Pinto SL, Oliveira CJ, Alencar AMPG. Technologies used by nursing to predict clinical deterioration in hospitalized adults: a scoping review. Rev Bras Enferm. 2022;75(5):e20210570. https://doi.org/10.1590/0034-7167-2021-0570

Corresponding author:
Érica Sobral Gondim
E-mail: erica.sobral@urca.br

Submission: 09-16-2021 **Approval:** 04-12-2022

ABSTRACT

Objective: to map the early clinical deterioration technologies used in nurses' professional practice in the care of hospitalized adult patients. **Methods:** this is a scoping review, according to Joanna Briggs Institute Reviewer's Manual, which seeks to map the main technologies for detecting early clinical deterioration of hospitalized patients available for use by nurses, summarizing them and indicating gaps in knowledge to be investigated. **Results:** twenty-seven studies were found. The most present variables in the technologies were vital signs, urinary output, awareness and risk scales, clinical examination and nurses' judgment. The main outcomes were activation of rapid response teams, death, cardiac arrest and admission to critical care units. **Final considerations:** the study emphasizes the most accurate variables in patient clinical assessment, so that indicative signs of potential severity can be prioritized to guide health conducts aiming to intervene early in the face of ongoing clinical deterioration. **Descriptors:** Technology; Nursing; Clinical Deterioration; Inpatients; Patient Safety.

RESUMO

Objetivo: mapear as tecnologias de deterioração clínica precoce utilizadas na prática profissional do enfermeiro na assistência a pacientes adultos hospitalizados. **Métodos:** trata-se de *scoping review*, segundo *Joanna Briggs Institute Reviewer's Manual*, que busca o mapeamento das principais tecnologias para detecção de deterioração clínica precoce de pacientes hospitalizados disponíveis de uso do enfermeiro, sumarizando-as e indicando lacunas no conhecimento a serem investigadas. **Resultados:** foram encontrados 27 estudos. As variáveis mais presentes nas tecnologias foram sinais vitais, débito urinário, escalas de consciência e riscos, exame clínico e julgamento do enfermeiro. Os principais desfechos foram acionamento de times de resposta rápida, morte, parada cardiorrespiratória e admissão em unidades de cuidados críticos. **Considerações finais:** o estudo enfatiza as variáveis mais acuradas na avaliação clínica do paciente, para que se possam priorizar sinais indicativos de potencial gravidade para guiar condutas em saúde visando intervir precocemente diante da deterioração clínica em curso.
Descritores: Tecnologias; Enfermagem; Deterioração Clínica; Pacientes Internados; Segurança do Paciente.

RESUMEN

Objetivo: mapear las tecnologías de deterioro clínico precoz utilizadas en la práctica profesional de enfermeros en el cuidado de pacientes adultos hospitalizados. **Métodos:** se trata de una revisión de alcance, según el Manual del Revisor del Instituto Joanna Briggs, que busca mapear las principales tecnologías para la detección temprana del deterioro clínico de los pacientes hospitalizados disponibles para uso de enfermería, resumiéndolas e indicando lagunas de conocimiento para ser investigadas. **Resultados:** se encontraron 27 estudios. Las variables más presentes en las tecnologías fueron signos vitales, gasto urinario, escalas de conciencia y riesgo, examen clínico y juicio de enfermería. Los principales desenlaces fueron activación de equipos de respuesta rápida, muerte, paro cardíaco e ingreso a unidades de cuidados críticos. **Consideraciones finales:** el estudio enfatiza las variables más precisas en la evaluación clínica del paciente, de modo que los signos indicativos de gravedad potencial puedan ser priorizados para orientar conductas de salud con el objetivo de intervenir tempranamente ante el deterioro clínico en curso.
Descriptores: Tecnología; Enfermería; Deterioro Clínico; Pacientes Internos; Seguridad del Paciente.

ONLINE VERSION ISSN: 1984-0446

INTRODUCTION

Hospitalization raises a greater demand for care and requires monitoring by a multidisciplinary health team so that the state of health can be safely reestablished[1]. Individuals who experience the hospitalization process are susceptible to an unfavorable evolution of the pathology presented, which can culminate in complications and increased mortality, if this progressive worsening, the deterioration of their clinical condition, is not observed in a timely manner[2].

When there is ongoing physiological deterioration, the installation of a condition compatible with the worsening of the disease is intuitively preceded by physiological parameters[3]. Any scale or scoring system that produces a score capable of classifying the risk of clinical deterioration of hospitalized patients, before its installation, is considered a technology to predict clinical deterioration[2]. It enables the prevention of unfavorable outcomes in sectors where monitoring of vital signs is not continuous and the number of patients under observation by the team is greater, such as in clinical-surgical wards[2-3].

Several technologies of early clinical deterioration have been increasingly developed, since 1997, for application in the routine work by the care team, either with simple models of manual implementation[4-7] or with complex algorithms integrated into computerized health record systems[8-11].

The management of potentially serious patients in clinical-surgical wards, whose complexity is incompatible with the human and technological resources commonly available in non-critical sectors, requires a careful assessment, guided by priorities, in order to detect signs of aggravation that indicate follow-up at a higher level of care[1]. Thus, knowledge of accurate assessment methods with rapid detection and immediate response is essential, with a view to patient safety and favorable prognosis, enabling the choice of the most appropriate technology for the institutional reality.

The most common parameters assessed in these technologies are vital signs (systolic blood pressure, heart rate, body temperature, respiratory rate and oxygen saturation) and level of consciousness[12-13]. Studies compare its effectiveness when variables such as laboratory tests are added in the assessment, resulting in more accurate models for certain outcomes[14].

Another important measure that demonstrates relevance is nursing professionals' clinical judgment, whose intuition demonstrates reliability consistent with the time of experience in the area of expertise[14]. The role of nursing in the development and implementation of these systems is remarkable, as some scores already include records and assessment scales for the use of these professionals[4,15] in assessing the risk of clinical deterioration. Such findings emphasize the importance of seeking the nurses' perspective in relation to clinical assessment and early recognition of signs of complications that can be immediately preventive intervention, being the professionals with adequate technical competence for risk assessment and the closest continuously to patients[14], being commonly the first professional to notice subtle changes in patients' clinical parameters.

OBJECTIVE

To map the early clinical deterioration technologies used in nurses' professional practice in the care of hospitalized adult patients.

METHODS

Ethical aspects

As this was a review study, the review by a Research Ethics Committee was waived. Rigor was required to follow the Joanna Briggs Institute (JBI)[16] methodological strategy for scoping reviews.

Study design

This is a scoping review, which seeks to map the main technologies for detecting early clinical deterioration of hospitalized patients available for use by nurses, summarizing them and indicating gaps in knowledge to be investigated.

Methodological procedures

The study followed the JBI Reviewer's Manual[16] instructions for scoping reviews, through the following steps: research question identification; relevant study identification; study selection; data mapping; data grouping, summarization and presentation[16]. The Extension for Scoping Reviews (PRISMA-ScR) checklist[17] and the recommended data collection and extraction instruments guided the development of this study.

For formulating the guiding question, the mnemonic PCC (P-Population; C-Concept; C-Context) was applied, in which the population consisted of adults hospitalized in clinical-surgical wards; the concept, the technologies for predicting clinical deterioration of nursing use in the hospital context.

Thus, it was defined as a research question: what are the technologies for predicting clinical deterioration in the use of nurses in the care of hospitalized adults?

Data collection and organization

The search was performed in the Medical Literature Analysis and Retrieval System Online (MEDLINE), The Cumulative Index to Nursing and Allied Health Literature (CINAHL) via EBSCO, Scopus (Elsevier) and Web of Science platform databases, from April to June 2021. Gray literature was also included in the sample, consisting of articles and manuals on the subject cited in the references of studies selected in the first step, the most comprehensive of the search in the databases.

The first step of the search was carried out in the MEDLINE and CINAHL databases. Broad descriptors were used in the area of knowledge, Clinical Deterioration and Inpatients, indexed in the Medical Subject Headings (MeSH), using only the Boolean operator AND in the crossover, to optimize the search for specific subjects within the broad area of knowledge. From the reading of titles and abstracts from the search, keywords were selected for the intersection of the second stage.

In the second step, MeSH descriptors corresponding to the keywords of the previous step were crossed, such as injury severity score, deterioration, inpatients, early warning score and risk assessment, with the following search strategies, still using the Boolean AND: injury severity score AND clinical deterioration AND inpatients; early warning score AND risk assessment AND inpatients; and early warning score AND clinical deterioration AND inpatients (Chart 1).

Inclusion criteria were original studies, literature reviews, monographs, theses, dissertations, editorials, without language restriction and published from 1997 onwards, when the first early warning score (EWS) was empirically created by Morgan et al.[18]. Studies related to adult patients hospitalized in clinical-surgical wards were included.

As for the exclusion criteria, studies directed to patients with specific clinical conditions were removed from the sample (pregnancy, sepsis, cancer, psychiatric disorders, palliative care, neurodegenerative and nutritional disorders, COVID-19, disorders of individual organ systems), in order to avoid bias in targeting technologies to restricted frames of pathologies.

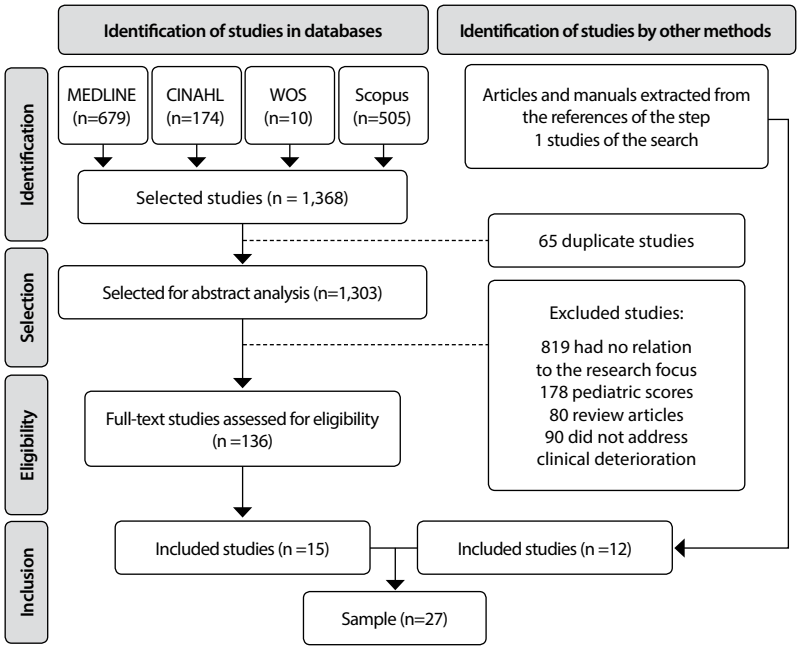

Figure 1 – PRISMA Flowchart adapted from PRISMA-ScR according to Joanna Briggs Institute[17], Brazil, 2021

Studies that addressed the recognition of clinical deterioration in pre-hospital care, in emergency departments, were also removed, as they are understood as services in which patients already have an initial picture of acute symptoms, and not evolution and follow-up, as appropriate for this type of assessment, in addition to those after discharge from the Intensive Care Unit (ICU), whose follow-up characteristics and imminence of complications are peculiar. Differences between the reviewers regarding the exclusion of selected articles were resolved by a third party, elected from among the authors.

After applying the inclusion and exclusion criteria and selecting the sample, a full reading was performed in order to elect those that deal with systems, scores, programs and other early warning technologies of clinical deterioration in nursing use.

In the third and final stage, which included the search in gray literature, titles and abstracts of the references of articles selected in the first stage were analyzed. So, 12 additional references were identified that dealt with technologies for predicting clinical deterioration, resulting in a final sample of 27 studies.

The study selection and sample composition process is shown in the flowchart (Figure 1), built according to JBI recommendations based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR)[17].

Data analysis

Data extraction from the studies was performed in a paired and independent way, using the standardized data extraction tool recommended by JBI[17], containing data, such as author, year of publication, place where it was conducted, objective, methods, outcomes and key findings related to the review question. The mapping of results through a table or form, most used in scoping reviews, allows a descriptive summary of the results in line with the objective and the question[17]. This conformation made it possible to organize the production characterization data and the response to the research problem, with subsequent comparative and descriptive analysis.

The level of evidence characterization variable was based on the Oxford Center Evidence-Based Medicine[19], which classifies studies based on their design into ten decreasing levels of evidence, namely: 1a (systematic review of randomized clinical trials); 1b (randomized controlled clinical trial with narrow confidence interval); 1c (all-or-nothing therapeutic outcomes); 2a (systematic review of cohort studies); 2b (cohort study); 2c (observation of

Chart 1 – Crossings in databases and second step of the search sample, Brazil, 2021

Keyword search	Scopus	WOS	MEDLINE	CINAHL
(injury severity score) AND (clinical deterioration) AND (inpatients)	4	0	5	0
(early warning score) AND (risk assessment) AND (inpatients)	209	1	62	4
(early warning score) AND (clinical deterioration) AND (inpatients)	292	9	66	7
TOTAL = 659	505	10	133	11

therapeutic results; ecological study); 3a (systematic review of case-control studies); 3b (case-control study); 4 (case reports); and 5 (expert opinion).

RESULTS

The studies were characterized and distributed in two tables, contemplating variables of identification and measurement of technologies, respectively.

In Chart 2, each study was identified by a letter (A) and a sequential number corresponding to the main author, year of publication, country of origin, type of study, level of evidence (LoE) according to the Oxford Center for Evidence-Based Medicine[19] and its objectives.

The 27 studies in the sample were published in different journals between 2001 and 2021, mostly from the United States (40.7%), followed by the United Kingdom (29.6%), another important research center. In Central and South America, no studies on this topic were found.

Many of the articles included in this review had a high level of evidence, due to their study types. The cohort ones (prospective and retrospective) were the most frequent (40.7%), covering accuracy measurement methods, prognostic criteria and technology validation.

With the same level of evidence from the cohorts, cross-sectional, non-randomized clinical trial, quasi-experimental, case-control and mixed methods studies were found, developing or analyzing the impact of a clinical deterioration risk assessment system in order to validate it. Those with the lowest level of evidence (3b, 4 and 5) constituted a minority in the sample findings (33.3%).

The studies were predominantly articles (92.6%) dealing with technologies for assessing clinical deterioration of patients hospitalized in a medical-surgical ward and related to nursing care. In addition to these, two manuals for the use of scores in clinical practice were found (7.4%).

The details were organized in Chart 3 below, with a breakdown of each technology presented, its outcomes and measured variables.

A heterogeneous variety of instruments was found in literature: simple scoring-based models; complex multivariable systems; adaptations of already validated scales; algorithms for generating scores in electronic medical records; nursing observation charts; patient or professional subjective judgment questionnaires on clinical condition assessment; and more complex items subdivided to assess different outcomes.

Among the technologies, most (92.6%) were based on vital signs and neurological, renal, pulmonary organic assessment parameters (70.4%) and serum biochemical markers (33.3%). Nurses' participation in the context of mapped technologies supports the importance of their performance in predicting clinical deterioration, since the critical look of this professional towards patients at risk is part of the structure of early detection technologies.

The nursing perspective was present in 9 studies (33.3%), emphasizing variables such as: pain scales; sedation and risks of falling and skin injury; nursing grades and clinical assessment of nurses, both subjectively (a factor of concern) and individualized by organic system (cardiac, respiratory, gastrointestinal examination); peripheral circulation; airway patency; gasometric assessment; and shock index calculation.

DISCUSSION

In 1997, Morgan et al.[18] empirically debated the use of a scoring system, based on patients' clinical condition, to direct care in non-critical units, so that they could be monitored and the risks of adverse events and in-hospital mortality were minimized. It was a milestone for a decade dedicated to investigating such iatrogenic care and their additional costs to health systems, such as the *To Err is Human* publication[36], highlighting patient safety worldwide.

Emphasis on patient safety since the 2000s, after the publication of the *To Err is Human* report[36], corroborates the growing number of studies in the two decades following it, with intensified research on technologies to identify clinical deterioration aimed at hospitalized patients in the last 10 years. The increase in the number of studies may also be associated with the expansion of

Chart 2 – Characterization of articles that composed the study sample, Brazil, 2021

ID	Reference	Country	Design	LoE	Objective
A1	Fogerty et al. (2018)[20]	United States	Observational prospective	3b	Develop and examine the use of a low-cost deterioration detection tool based on the Systemic Inflammatory Response Syndrome (SIRS) criterion.
A2	Albutt et al. (2020)[21]	United Kingdom	Mixed methods	4	Develop and assess a method of patient involvement in clinical deterioration recognition and explore its feasibility and acceptability from patients' perspective.
A3	Luis e Nunes (2018)[5]	Portugal	Cohort	2b	Assess whether a simplified National Early Warning Score (NEWS) model will improve data use and collection.
A4	Kia et al. (2020)[8]	United States	Cohort	2b	Describe an artificial intelligence model that enables the identification of patients at risk of escalation of care or death six hours before the event.
A5	Kirkland et al.(2013)[4]	United States	Case-control	2b	Create and validate a clinical deterioration prediction tool using routinely collected nursing and clinical measures.
A6	Prytherch et al. (2010)[22]	United Kingdom	Cohort	2b	Develop a screening and triggering system for early warning of patient deterioration detection.

To be continued

Chart 2 (concluded)

ID	Reference	Country	Design	LoE	Objective
A7	Romero-Brufau et al. (2019)[14]	United States	Cohort	2b	Assess the accuracy of nurses' judgment in detecting imminent physiological deterioration.
A8	O'Connell et al. (2016)[6]	Australia	Retrospective observational	4	Assess the impact of a new standardized observation and response chart.
A9	Paterson et al. (2006)[23]	Scotland	Cohort	2b	Assess the impact of introducing a standardized early warning scoring system on patient assessments and outcomes in acute admissions.
A10	Kyriacos et al. (2014)[24]	South Africa	Methodological study	5	Develop and validate an observation chart for nurses incorporating an early warning scoring system with physiological parameters for bedside monitoring in general wards in a public hospital in South Africa.
A11	Pirret e Kazula (2021)[25]	New Zealand	Mixed methods	2b	Determine the impact of modified NZEWS (M-NZEWS) and NZEWS as emergency team activation triggers on medical ward patients.
A12	Gillies et al. (2020)[26]	United States	Cohort	2b	Develop a new early warning system (PICTURE) to predict deterioration of hospitalized patients.
A13	Capan et al. (2018)[27]	United States	Retrospective observational	4	Develop and assess a systematic approach to managing an early warning system.
A14	Churpek et al. (2014)[9]	United States	Cohort	2b	Develop and validate a prediction model to detect cardiac arrest using data from electronic medical records.
A15	Rothman et al. (2013)[15]	United States	Survey	1c	Report the development and validation of a continuous measure of general clinical condition that can be used for medical-surgical and critical care patients.
A16	Royal College of Physicians (2012)[12]	United Kingdom	Expert opinion - Manual	5	Provide training support for in-service use of NEWS.
A17	Jarvis et al. (2015)[7]	United Kingdom	Cohort	2b	Develop the binary NEWS, investigating the effectiveness of two possible scores for each vital sign.
A18	Subbe et al. (2001)[28]	United Kingdom	Cohort	2b	Assess the ability of a modified EWS to identify at-risk clinical patients and as an early assessment screening tool for admission to a high-dependency unit.
A19	Kho et al. (2007)[10]	United States	Cohort	2b	Assess whether an automatically generated scale based on data from an electronic medical record can accurately detect patients at risk for cardiovascular collapse, death, or ICU transfer.
A20	Smith et al. (2006)[29]	United Kingdom	Case series	4	Describe a bedside vital sign collection system using standardized personal digital assistant (PDA) integrated with physiological and laboratory data to assess disease severity and support clinical decision.
A21	Hodgetts et al. (2002)[30]	United Kingdom	Quasi-experimental	2b	Identify risk factors for in-hospital cardiac arrest (CA), formulate medical emergency team (MET) activation criteria, and assess sensitivity and specificity for the scoring system.
A22	Nishijima et al. (2016)[31]	Japan	Non-randomized clinical trial	2b	Detect abnormalities early by vital sign classification.
A23	Preece et al. (2010)[32]	Australia	Case series	4	Investigate the effectiveness of observation charts in recognizing and managing deterioration.
A24	Chatterjee et al. (2005)[33]	United Kingdom	Cohort	2b	Assess whether the approach to redrawing observation chart improves detection of physiological decline.
A25	Bailey et al. (2013)[11]	United States	Crossover	1b	Prospectively validate a predictive algorithm of clinical deterioration in general medical ward patients and conduct an assay based on this algorithm.
A26	Jacques et al. (2006)[34]	Australia	Cross-sectional	2b	Establish an association between records of altered physiological variables and adverse events.
A27	Kollef et al. (2016)[35]	United States	Retrospective observational	3b	Determine the potential influence of a rapid response system employing real-time clinical deterioration alerts (RTCDAs) on patients at eight general medical facilities.

Note: ID – study identification code; LoE – level of evidence; ICU - Intensive Care Unit.

Chart 3 – Characterization of studies regarding the technologies used, their respective outcomes and measured variables, Brazil, 2021

ID	Technology	Outcomes	Variables measured for determination of clinical deterioration					
			BP	HR	RR	T	SPO_2	Other
A1	SIRS-based automated alerting	ICU transfer and death	X	X	X	X		Laboratory tests
A2	Patient Wellness Questionnaire (PWQ)	Self-perceived wellness						Ability of patients to recognize deterioration
A3	Short NEWS	ICU transfer and death	X	X	X		X	Oxygen therapy, level of consciousness
A4	MEWS++	ICU transfer and death	X	X	X		X	Demographic variables, level of consciousness, admission and stay characteristics, laboratory tests, clinical examinations and nursing notes *
A5	Clinical deterioration prediction tool	Clinical deterioration	X		X	X	X	Braden scale, shock index, fall risk scale
A6	VitalPAC- EWS (ViEWS)	Discharge status and rapid response team (RRT) triggers	X	X	X	X	X	Level of consciousness
A7	Nurses' Worry Factor (WF) score	CA, RRT triggers, ICU transfer						Nurses' clinical judgment*
A8	Standardized observation and response chart	CA, RRT triggers, ICU transfer, death		X	X	X	X	Oxygen therapy, level of consciousness and sedation, pain scale
A9	Early warning scoring system chart (SEWS chart)	Parameter registration and death	X	X	X	X	X	Level of consciousness
A10	MEWS chart	Clinical deterioration	X	X	X	X	X	Urinary output, level of consciousness
A11	Modified NZEWS (M-NZEWS) and NZEWS	CA, RRT triggers	X	X	X	X	X	Level of consciousness, oxygen therapy
A12	PICTURE	ICU transfer, vasoactive medication administration, death	X	X	X		X	Oxygen therapy, Glasgow Coma Scale, urine output, laboratory tests, calculated values (shock index, age x shock index, pulse pressure)
A13	Christiana Care Early Warning Score (CEWS)	RRT and composite event triggers (RRT trigger, code blue activation, ICU transfer or death)	X	X	X	X	X	Level of consciousness, oxygen therapy and 8 clinical assessments derived from nursing assessments *
A14	Prediction model for adverse outcomes in wards	CA and ICU transfer	X	X	X	X	X	Laboratory tests, patient characteristics (age, level of consciousness, ambient air, previous ICU stay)
A15	Rothman Index	Discharge readiness, 30-day readmission, clinical deterioration, CA, and death	X	X	X	X	X	43 candidate variables: 13 nursing assessments*, 6 vital signs, 23 laboratory tests and heart rate monitoring
A16	NEWS	Death	X	X	X	X	X	Level of consciousness and oxygen therapy
A17	Binary NEWS	CA, ICU transfer and death	X	X	X	X	X	Oxygen therapy, level of consciousness
A18	Modified Early Warning Scale (MEWS)	RRT triggers, ICU transfer, and death	X	X	X	X		Demographic data, level of consciousness
A19	Automatic scoring system with electronic medical record data	RRT triggers by CA, ICU transfer and death	X	X	X	X		Age and Body Mass Index (BMI)
A20	Hospital patient surveillance system	Disease severity, potential risk of developing adverse outcome	X	X	X	X		Level of consciousness, urinary output, laboratory tests
A21	Risk scoring system for hospital CA with criteria for alerting the MET	CA	X	X	X	X	X	Nurses' clinical judgment*, urinary output, level of consciousness, pain

To be continued

Chart 3 (concluded)

A22	Modified MEWS	CA	X	X	X	X		Level of consciousness, nurse's concern about patients' condition
A23	Adult Deterioration Detection System (ADDS chart)	Clinical deterioration	X	X	X	X	X	Oxygen therapy, urinary output, level of consciousness, pain
A24	Bedside observation chart (OBS chart)	Clinical deterioration	X	X	X	X	X	-
A25	Deterioration prediction tool with real-time alert algorithm	Length of hospital stay, ICU transfer and death	X	X	X		X	Shock index, anticoagulant use, age, laboratory tests
A26	Signs of Critical Conditions and Emergency Response (SOCCER)	Severe respiratory problems, CA, ICU transfer and death	X	X	X		X	Variables (e.g., level of consciousness, urinary output, laboratory tests) listed in 02 tables: 1 with 26 early signs and another with 21 late signs of critical conditions
A27	Rapid response system and automated real-time clinical deterioration alerts	CA, length of hospital stay and death	X	X	X		X	Shock index, change in clotting

*Note: ICU – Intensive Care Unit; MET – medical emergency team; CA – cardiac arrest; BP – systolic blood pressure; HR – heart rate; RR – respiratory rate; T – body temperature; SPO2 – oxygen saturation; *Studies that bring specific nurses' assessment variables.*

advanced nursing practices, having as a milestone the publication in 2008 of its definitions and characteristics by the International Council of Nursing[37].

The findings demonstrate the relevance of technologies for predicting clinical deterioration for safe nursing practice, explaining its technological evolution from 1997[18] to the present day[25].

The United States and the United Kingdom, world powers and major centers of reference in health research, were responsible for most studies in the sample referring to clinical deterioration as a predictor of adverse health events in hospitalized patients. This search for "a perfect score" is in line with commitments agreed with global organizations, including mobilization campaigns, to reduce serious adverse events and improve patient safety[36].

Despite the long period in which it has been studied, the topic remains on the rise to this day, including scores for specific audiences, sectors and/or clinical conditions. Pediatric, obstetric, mental illness prediction systems, applied in emergency or pre-hospital departments, predictive of sepsis, COVID-19, respiratory and cardiac pathologies are some technologies found in literature[13,20].

The inexhaustibility of this study on the subject is noticeable when one observes researchers who have remained in this line of research since 2012, such as Dr. Matthew Churpek, who developed and validated clinical deterioration scores and subsequently conducted research, such as a multicenter cohort, comparing different techniques for detecting deterioration in wards[38].

A possible justification for continuity of research is the fact that the primary outcome of hospital mortality does not present, so far, significant positive results that point to an ideal score[25]. There were many benefits, such as an increase in activation of RRT, in the number of early admissions to ICUs, a reduction in the occurrence of cardiac arrest in the wards, but the reduction in overall hospital mortality was not impactfully achieved by the technologies studied[2].

Under the context of nursing practice, the screening of clinical signs of deterioration and their intervention are emphasized in several stages of the process. Playing roles from the assessment of specific parameters and scales, acting in RRT, perception of clinical worsening and risk management of adverse events, their actions are based on patient safety policy which are indicative of quality of care[37].

Diversified instruments for measurement and intervention have been developed and optimized in this sense, using their validation to achieve greater accuracy and improvement in early detection for preventive interventions to unfavorable outcomes[16,28]. Nurses have been active subjects in the development of prediction systems (A5, A7, A10), especially in recent years, in which professional empowerment and the evolution of advanced nursing practices cover a scope of action with greater complexity and autonomy[37].

Nursing performance in the context of predicting clinical deterioration is present from the simple role of measuring and recording basic parameters, such as vital signs, even in the measurement of urinary output and level of consciousness, assessments that are already present in their professional routine and that are provided for in professional practice regulations[39].

Monitoring the evolution of patients in the wards, whether through empirical observation based on experience and a critical eye or through the Systematization of Nursing Care, is proven to be effective in the early recognition of signs that indicate a clinical deterioration in a facility[14]. This data reinforces the justification for the use of professionals' clinical judgment in the variables measured in some systems (A7).

Moreover, validated scales for nursing use, such as the Braden Pressure Injury Risk Scale, the Hendrich II Fall Risk Scale, among others, are included in the construction of some technologies to assess the risk of clinical deterioration (A5, A8, A15). Parameters related to laboratory tests, present in most instruments with a more complex approach, although routinely assessed by assistant physicians, are increasingly also being interpreted and assessed by nurses in their clinical decision-making[37,39].

The scope of advanced nursing activities, as well as the demand of critically ill patients in the wards, are growing and disproportionate to the supply of professionals trained to recognize signs of complications and offer safe care[37]. Follow-up measures that guide interventions and predict adverse events are fundamental, emphasizing the indispensability of creating technologies to

predict clinical deterioration with proven accuracy both in reducing mortality and in reducing "false calls" of RRT, which cause fatigue of professionals and trivialization of alarms[35].

Two manuals found in the sample instructing on the implementation of validated systems, NEWS and ADDS[12,32], indicated the need for training in the use of these technologies for professional training and effective use in service, emphasizing the relevance of the evolution of advanced nursing practices and the need for continuing education.

The reflexes appear in qualification of care. When anamnesis and physical examination are used to assess patients and outline their care plan, nurses include items that delimit the degree of complexity and indicate aggravation of the disease in the facility. As for the technologies found in the studies, signs of complications present in the clinical examination awaken the nursing perception and enable the formation of judgment capable of predicting an assertive decision-making[37]. The application of pain, sedation and risk of adverse events scales complements the comprehensiveness of the typical thorough assessment of advanced practice nurses[37].

The findings point to the existence of a gap that shows few technologies built by nurses based on their scope of action that are feasible and complementary to the Nursing Process, able to predict clinical deterioration for decision making and prevention of adverse events based on expected outcomes and nursing interventions. New studies are suggested for the development and validation of new technologies, specific to nursing, which have practical applicability at the bedside and effective performance in the prevention of adverse events.

Study limitations

A limitation would be the intersection of competences common to health team professionals in the performance in predicting risks to patients, the attributions of each one of them not being specified in the studies.

Contributions to nursing, health, and public policies

Survey of scientific evidence, in addition to that already widely used, and use of MEWS score in the assessment of risk of clinical deterioration, providing the dissemination of varied technologies and additional data capable of optimizing nursing assessment, and thus preventing aggravation of patients' condition.

FINAL CONSIDERATIONS

When mapping the technologies available for use by nurses in the assessment and prediction of clinical deterioration, one can see the plurality of existing tools that can be implemented in the work routine, capable of reducing risks to patients and enabling early intervention in the face of the possibility of aggravation.

Although they are not specifically used by a particular professional in the health team for assessing adult patients hospitalized in clinical-surgical wards, these technologies include nursing assessments among the variables addressed, depending, therefore, on the direct performance of nurses, in addition to some containing questions of their professional competence with regard to direct care for critically ill patients.

Among the technologies mapped, most addressed parameters and observations that are already routine nursing assessment, such as measuring vital signs and urinary output, risk measurement and use of cognition/sedation scales, oxygen therapy management, physical examination and nursing notes. The importance of this study in this context is to emphasize the most accurate variables in patients' clinical assessment, so that signs indicative of potential severity can be prioritized to guide health conducts, aiming to intervene early in the face of ongoing clinical deterioration.

It was possible to identify the presence of nurses' role in improving these technologies. His clinical judgment was considered to have an impact on the accuracy of developed systems. Among those that contained specific nursing items, six studies highlighted variables such as a factor of concern, nursing records and assessments, risk scales for falls and pressure injuries. In addition to these, the measurements of vital signs, urinary output and the physical examination itself, which originates the nursing reports, are already part of their attributions and are present in most technologies for predicting clinical deterioration.

The difficulties in implementing these technologies in clinical practice stem from inappropriate infrastructure and human resources, since nursing sizing in the wards is not usually performed due to patient complexity and there is no equipment for continuous monitoring of vital signs as a routine. Vital signs are measured at infrequent intervals, delaying the detection of the first changes in real time.

Although the nursing component appears strongly in these technologies, there are few models developed by nurses to support their own assessment. Most are focused on medical interpretation and judgment. No publications were found on the development and validation of nursing technologies for early warning of clinical deterioration in Brazil.

In the current context of patient safety culture and the growth of advanced evidence-based nursing, there are gaps in the development of predictive technologies for early warning of clinical deterioration in healthcare settings. Models that consider peculiarities of hospital setting, patient profile and nursing would enable new horizons to achieve quality care with minimal risk reduction.

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