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ORIGINAL ARTICLE

EFFECTIVENESS OF AN ALGORITHM TO IDENTIFY EARLY CLINICAL DETERIORATION IN ADULT INPATIENT UNITS[1]

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ABSTRACT

Objective: To evaluate the effectiveness of an algorithm for early identification of clinical deterioration in adult inpatient units. **Method:** Retrospective cohort study conducted in a philanthropic hospital in northern of the State of Paraná. The study analyzed the trend of indicators related to productivity, production, and quality. It adopted an alpha error of 5%. **Results:** The production indicators showed a decreasing trend in the occupancy rate, both of the beds destined for elective treatments and those reserved for urgency, and an increasing trend in the absolute number of hospitalizations and the number of patients per day. The productivity indicators showed a steady trend in the bed renewal index. Regarding quality, there was a predominance of increasing trend in all rates (infection, sepsis, and mortality). **Conclusion**: The results showed that the algorithm was effective since there was an improvement in production indicators, which showed a decreasing trend in the occupancy rate, both in elective and emergency beds, and productivity indicators, where there was a stationary trend in the bed renewal index.

Keywords: Clinical deterioration. Inpatient care units. Indicators of health services.

INTRODUCTION

Clinical deterioration is characterized as a predictable and symptomatic process caused by a sudden worsening of the physiological conditions of the individual, or an acute alteration of the clinical state of the individual, resulting in organic disorders that, in themselves, are related to an increase in the individual risk of morbidity, prolonged hospitalization, disability or death(1).

Considering that early identification and intervention in such manifestations can reduce in-hospital morbidity and mortality, at the end of the twentieth century, studies emerged intending to establish parameters that would allow the monitoring of the clinical evolution of patients at the bedside by monitoring signs indicating clinical deterioration through measurement instruments(2).

Instruments for measuring clinical deterioration usually use vital data to monitor patients' health during their hospitalization. They are considered effective when they can identify the risk of clinical deterioration earlier, through signs of complications amenable to preventive intervention(3).

The first instrument to measure clinical deterioration was the Early Warning Score (EWS), implemented 1997 in the United Kingdom, in manual medical records, with the aim of training professionals in the evaluation of patients, relating altered physiological signs with possible serious events(2).

After the satisfactory result of the implementation of the EWS, it was elaborated, based on the previous instrument, the Modified Early Warning Score (MEWS), which also focuses on the evaluation of vital parameters, such as level of consciousness, blood pressure, heart rate, respiratory rate, and body temperature;

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this instrument, in turn, proved to be a simple and helpful tool for identifying patients at risk of deterioration and can be applied at the bedside[4].

Other instruments for assessing clinical deterioration have been developed or improved and are part of the routine assessment of hospitalized patients in several countries[3], such as the Early Warning Scoring System (NEWS)[5], also found in electronic format (E-NEWS), as the logistic model (logEWS)and dynamic model (DyniEWS)[6]. Used mainly in the United Kingdom, it aims to identify patients most likely to be transferred to the intensive care unit (ICU).

The prognosis of clinical deterioration through computerized scales collaborates so that clinical decisions are faster and more assertive. Some parameters can be analyzed using digital algorithms, which are instructions carried out systematically through computational commands and whose objective is to solve a problem or perform an action[7-9].

The use of technology in the care of hospitalized patients, in addition to contributing to predict risks or minimize health problems, positively impacts on the improvement of quality indicators, production and hospital productivity, as these are components of the care process[10].

Given this scenario, the elaboration of strategies and adherence to means that enable the early identification of clinical deterioration of patients is of paramount importance to improve the quality of healthcare.

Therefore, this study aimed to evaluate the effectiveness of an algorithm to verify the early clinical deterioration of patients in adult inpatient units, in parameters of production, productivity and quality.

METHOD

This is a retrospective cohort study that classified the observed individuals as exposed or not exposed to risk factors for clinical deterioration, which was evaluated using an algorithm installed in a cognitive robot. The study used the Strengthening the Reporting of Observational studies in Epidemiology (STROBE)[11] that guides observational studies.

The research was conducted in a philanthropic hospital of high complexity, with approximately 200 beds, located in the north of Paraná (PR), Brazil, affiliated with the Unified Health System (SUS). This institution has 36 intensive care beds and eight operating rooms. The study included patients older than 18 years old, hospitalized in adult inpatient units in medical or surgical clinics. As exclusion criteria, it established that patients hospitalized in intensive care units (ICUs), emergency rooms (ER), and undergoing palliative care would not be considered.

In the present study, the algorithm installed in the cognitive robot was adapted from the MEWS instrument[4], which uses vital parameters to identify early clinical deterioration of patients, as shown in Chart 1.

Chart 1. Digital algorithm installed in a cognitive robot for early identification of clinical deterioration, Londrina/PR, 2021

Parameters	Points						
	3	2	1	0	1	2	3
RR (bpm)	≤ 8	≤ 8	----	9-11	12-20	----	21-24
Oximetry	≤ 91%	≤ 91%	92 – 93%	94-95%	≥ 96%	----	----
Temperature (°C)	≤ 35°C	≤ 35°C	----	35.1-36ºC	35.1-38°C	38.1-39°C	≥39.1°C
SBP (mmHg)	≤ 90	≤ 90	91 -100	----	101-110	----	----
HR (bpm)	≤ 40	≤ 40	----	41-50	51-90	91-110	111-130
Arterial pH	< 7.1	< 7.1	----	----	----	----	----
Arterial HCO3	< 10	< 10	----	----	----	----	----
Platelet	≤20.000	≤20.000	----	----	----	----	----
Hemoglobin	≤ 7	≤ 7	----	----	----	----	----
Sodium	≤ 120	≤ 120	----	----	----	----	----
Potassium	≤ 2,5	≤ 2,5	----	----	----	----	----
Elevation of creatinine	100%*	100%*	----	----	----	----	----
* In relation to the previous examination							

Source: adapted from Prytherch et al.[12]

Legend: RR: respiratory rate; bpm: breathes per minute; SBP: systolic blood pressure; mmHg: millimeters of mercury; HR: heart rate; bpm: beats per minute; pH: hydrogenionic potential; HCO3: sodium bicarbonate.

The algorithm has previously undergone a content validation process by experts. The participants were eight medical specialists (two coordinators of the medical clinic, two of the surgical clinic, two intensivists, and two who worked in the Hospital Infection Control Commission), six resident physicians (one from each specialty – neurosurgery/neurology, gastroenterology, medical clinic, surgical clinic, urology, and orthopedics), as well as five nurse coordinators of the inpatient units. There were two meetings, with each specific group (doctors, residents, and nurses), lasting three hours, to clarify the objectives and operation of the algorithm.

The implementation of this algorithm was conducted using artificial intelligence through a cognitive robot, which is a software developed through two technologies: cognitive computing and machine learning, with the ability to identify symptoms of diseases through international standards and protocol, as well as hospital patient histories, when remotely connected to equipment and electronic medical records. When it identifies a relevant change, the robot emits an alert on the monitors scattered throughout the hospital. If the patient does not receive care, the robot forwards SMS messages and emails to specific teams. If the alert is still not answered after a specific time, the device sends messages to the management of the hospital service[(13)].

The algorithm installed in the cognitive robot was programmed with the parameters presented in Chart 1 to evaluate clinical deterioration. The institution in question has a computerized electronic medical record system, which enabled the use of such a technological resource fed by the information recorded in real-time in the electronic medical record.

The instrument evaluated the patients' vital and laboratory parameters every 3.8 seconds by software. Some scholars[(4)] who approached this type of instrument presented disagreements regarding the definition of the best cutoff score, which usually varies between three and ten.

After a test period, during the implementation of the algorithm in the institution that conducted the study, the multidisciplinary team (doctors, nurses, and residents), through clinical observations and support from the current literature[(4-5,8)], determined the cutoff point equal to 6 as the most appropriate for the prediction of clinical deterioration, considering the parameters described in Chart 1.

As the sum of the alterations presented by the patients approached the score elected as critical[(6)], the cognitive robot began to alert the team through a visual panel available in the nursing stations of all units, enabling the interaction of the robot interface with the health team. Thus, when the interface signaled a patient, it was possible to identify in which bed the patient was allocated and the reason for the alert. After the initial evaluation, carried out by the nursing team at the bedside, because it is a teaching hospital, the resident responsible for the patient was called for evaluation. After the analysis, if considered necessary, he called the incumbent physician.

When the patient's condition was stabilized and his/her score was reduced, the interface stopped the alarm, evidencing the appropriate management and the patient's stable stay in the inpatient units. If necessary, early transfer to the ICU was arranged.

This algorithm, implemented in July 2018, initially focused on patient safety. As a consequence, researchers expected that it would have a positive impact on some hospital indicators.

Although studies involving such instruments usually evaluate only three indicators (mortality rate, internal transfer to ICU, and cardiorespiratory arrest - CRA), this research analyzed productivity, production, and quality indicators[(14)].

The productivity indicators listed were: bed turnover renewal or turnover index (number of exits in a given period/number of beds in the same period), internal transfer to ICU (rate of patients who are transferred from wards or inpatient units to the ICU) and average days of stay in the inpatient unit (numerical relationship between the total amount of patients/day in a given period and the total number of patients who left, due to discharges and deaths)[(14)].

For the analysis of production indicators, the following were considered: occupancy rate (percentage between the number of patients/day and the number of beds/day in a given period, considering extra and blocked beds), the absolute number of hospitalizations and the number of patients/day. The quality indicators considered were: general mortality rate, mortality rate due to sepsis, and rate of infections related to healthcare (RIRH).

For the data collection of the indicators of production, productivity, and quality of the hospital, two distinct periods were evaluated: 09/01/2017 to 06/30/2018 and 07/01/2018 to 04/30/2019. For the patient data, the study considered the post-implantation period of the early deterioration algorithm, i.e., 07/01/2018 to 04/30/2019. Researchers collected the information from the hospital management system of the institution under study, known as Business Intelligence (BI), which constitutes tools, applications, and methodologies capable of accessing and examining data sets, presenting their results in analytical reports, summaries, graphical dashboards, and maps[15].

The program Statistical Package for the Social Sciences® (SPSS), version 20.0, analyzed the data. The descriptive data of the indicators under study were presented according to the mean and standard deviation, comparing the periods before and after the implementation of the algorithm.

For statistical analysis, since the analyzed indicators suffer the interference of factors related to the organizational structure and work processes, which could be considered as bias in the relationship between cause and effect, the study opted for a trend analysis of the data in the entire period, between September 2017 and April 2019.

A temporal analysis was performed with a trend component ($Y= \beta0+ \beta1X$), in which Y corresponds to the scale of values of the indicators in the time series (dependent variable), X refers to time (independent variable), $\beta0$ corresponds to the intersection between the line and the vertical axis (constant) and $\beta1$ corresponds to the slope of the line.

The research adopted as null hypothesis H0: $\beta1= 0$ (dependent variable does not present alteration); and as alternative hypothesis H1: $\beta1\neq 0$ (variable presents alteration). All indicators of production, productivity and quality were considered as dependent variables. It also classified the trends as increasing, decreasing or stationary, according to the slope of the line, and adopted an alpha error of 5%.

The research was developed respecting the ethical precepts required by Resolution nº 466/12 and was approved by the Research Ethics Committee under the Consubstantiated opinion nº. 3.915.731.

RESULTS

From 07/01/2018 to 04/30/2019, after the implementation of the algorithm, 593 patients in clinical deterioration were identified, with a predominant age range between 50 and 89 years (75.8%). Of these, 42.4% were women, and 57.5% were men.

Regarding the outcome presented by these patients, 93.6% were discharged from hospital, 4.3% were transferred to other institutions, and 2% died.

With regards to the changes presented in clinical parameters: 27.7% were related to Systolic Blood Pressure (SBP); 22.8% to temperature; 21.9% to oxygen saturation (Osa2); 13.9% to heart rate; 9.7% to respiratory rate; and 1.5% to creatinine. Changes in hemoglobin, potassium, sodium, bicarbonate (arterial HCO3), pH, and platelets, in descending order, were presented in a percentage lower than 1.

Table 1. The trend of productivity and production indicators in the periods before (01/09/2017 to 30/06/2018) and after (01/07/2018 to 30/04/2019) the implementation of the algorithm in a cognitive robot in a philanthropic hospital, Londrina/PR, 2021

Indicador	Before		After		Trend	
	Average	SD	Average	Average	SD	Average
Renewal or turnover ratio – units (%)	1,22	0,001	1,18	0,001	0,00	Stationary
Renewal or turnover ratio – UTI (%)	2,75	0,007	2,42	0,008	0,00	Stationary
Internal transfer to ICU (%)	39,67	0,022	40,35	0,024	0,02*	Growing
Average hospital stays (days)	8,62	0,696	7,74	0,656	-0,07*	Descending
Occupancy rate – elective (%)	23,48	0,027	23,38	0,023	-0,03*	Descending
Occupancy rate – urgency (%)	141,57	0,101	139,38	0,069	-0,24*	Descending
Absolute number of hospitalizations	701,33	53,568	753,78	53,568	4,29*	Growing
Number of patients/day	4090,33	279,85	4254,33	219,59	15,91*	Growing

* p-value < 0.05

Legend: $\beta1$= slope of the line; SD= standard deviation; ICU=Intensive Care Unit.

When checking the productivity indicators throughout the period (Table 1), the study observed a stationary trend in the bed turnover rate in the ICUs and the inpatient units. On the other hand, there was a significant increasing trend in the rate of internal transfer to the ICU and a decreasing trend in the average length of hospital stay

Concerning production indicators (Table 1), there was a significant downward trend in the occupancy rate, both in beds reserved for elective treatments and those destined for urgent care. An increasing trend is observed in the absolute number of hospitalizations and number of patients per day.

Most of the quality indicators showed a significant increasing trend in the period, with the exception of the mortality rate due to sepsis in the inpatient units, which showed a decreasing temporal trend, and the rate of hospital infection in the units, which showed a stationary trend (Table 2).

Table 2. The trend of quality indicators in the periods before (09/01/2017 to 06/30/2018) and after (07/01/2018 to 04/30/2019) the implementation of the cognitive robot in a philanthropic hospital, Londrina/PR, 2021

Indicador	Before		After		Trend	
	Average	SD	Average	Average	SD	Average
Overall mortality rate (%)	6,71	0,012	7,65	0,007	0,10*	Growing
Sepsis mortality rate – units (%)	8,68	0,031	6,58	0,030	-0,22*	Descending
Sepsis mortality rate – ICU (%)	48,43%	0,077	49,82	0,074	0,18*	Growing
Hospital infection rate – overall (%)	3,75	0,007	4,56	0,009	0,04*	Growing
Hospital infection rate – units (%)	1,24	0,005	1,37	0,004	0,00	Stationary
Hospital infection rate – ICU (%)	1,55	0,004	1,69	0,004	0,01*	Growing

* p-value < 0.05
Legend: β1=slope of the line; SD= standard deviation; ICU=Intensive Care Unit; CI = confidence interval.

DISCUSSION

The implementation of the algorithm through the cognitive robot proved to be effective, as it contributed to improve production indicators, which had a decreasing trend in the occupancy rate, both in elective and emergency beds; and productivity indicators, where the study observed a stationary trend in the bed renewal index.

Concerning quality indicators, they showed an increasing trend in most rates, especially those related to mortality from infection and sepsis, since the algorithm may have contributed to the early diagnosis of patients who presented clinical pictures related to these cases.

A study conducted in the countryside of the state of São Paulo, which evaluated the performance of a modified Early Warning Score (MEWS) in the inpatient units of a public hospital, identified that the tool could adequately quantify the number of significant serious events in hospitalized patients(16).

Of the patients identified by the algorithm, the study observed that the majority (93.5%) were discharged from the hospital, 4.3% died, and 2% needed to be transferred from the institution. It was not able to determine their final outcome. In a study conducted in Rio de Janeiro, which aimed to evaluate the implementation of a MEWS in a private philanthropic hospital, researchers found that, of the patients who had altered parameters and were identified by the score, 62% needed to be transferred to the ICU, 19% were stabilized in the inpatient unit and 16% were transferred to the emergency room. Death, cardiorespiratory arrest (CRA), and other events also had 1% prevalence (8).

The internal transfer rate to the ICU showed an increasing trend after the implementation of the algorithm, which can be justified by the early identification of patients at risk, with the consequent early intervention. However, a study conducted in Taiwan showed that, after the implementation of an early warning system to identify clinical deterioration, internal transfers to the ICU significantly decreased (3.63% to 3.49%, p=0.035)(17). Along with the increasing trend of unplanned transfers to ICUs, there was an increased trend in the rates of RIRH and sepsis mortality in these settings, assuming that the increase in transfers directly impacted these indicators.

On the other hand, in the inpatient units that implemented the algorithm, there was a decreasing trend in the sepsis mortality indicator and a stationary trend in the hospital infection index. A study conducted in Singapore[18], which used an algorithm for early detection of sepsis in hospitalized patients, identified the ability to detect 21% to 32% more, compared with medical forecasts 4-48 hours before the onset of sepsis.

The average length of hospital stay showed a decreasing trend, going from an average of 8.62 to 7.74 days, demonstrating that the alert issued by the cognitive robot allowed the team to make clinical decisions in a timely manner. A study conducted in the State of Rio Grande do Norte, which evaluated the efficiency of regional hospitals in the State, found an average stay of 9.4 and 3.5 days in large, medium and small institutions, respectively. The highest value (11 days) was found in a large health facility, which treated cases of high complexity[19].

Another study aimed to characterize the profile of Brazilian general hospitals that provide services to the Unified Health System (SUS) found an average stay of 6.45 days in institutions of greater complexity[20]. The same decline was observed in the occupancy rate of beds, both emergency and elective.

Finally, there was an increasing trend in the mortality rate and general hospital infection rate, which can be justified by the findings found in this study because although the rates showed a decreasing trend in the inpatient units where the cognitive robot was used, there was an increasing trend in these same indicators in the ICUs. It is noteworthy that the implementation of the algorithm for early detection of clinical deterioration in inpatient units allowed monitoring of the hemodynamic parameters of the patient in its entirety during the 24 hours of the day, facilitating the detection of any instability of this and its early transfer to the ICU.

Research conducted in the United Kingdom[21] demonstrated the benefits of using a clinical observation system based on EWS, associating a reduction of approximately 10% in the total number of unplanned hospitalizations in intensive care units of wards equipped with the technological resource.

The health teams of hospital units that have implemented early warning scores to identify clinical deterioration observed positive impacts on the reduction of morbidity and mortality indicators in hospitalized patients[22]. The insertion of technology as an ally in the development of care still encounters obstacles, especially in public hospitals, where financial resources are scarcer. In this sense, projects must be developed to ensure financing and subsidies for technological advancement.

In the literature, there are few studies available that address the evaluation of hospital indicators after the implementation of these tools. And, in short, these studies focus on three main indicators: cardiorespiratory arrest, internal transfer to ICU, and mortality, making it difficult to compare the indicators obtained between institutions.

Some of the limitations of this study are that it was conducted in a single hospital and did not evaluate patients in the ICU, which are the patients who present greater clinical instability. Another limitation was the lack of observation of indicators of the team’s ability to manage and interpret data for early assessment of deterioration.

CONCLUSION

The implementation of the algorithm to identify early clinical deterioration in hospitalized adult patients was effective since the production indicators showed a decreasing trend in the occupancy rate, both in elective and emergency beds; and the productivity indicators showed a stationary trend in the bed renewal index.

The use of technology as an ally in the development of care can be a collaborative factor for more favorable results to the patient, as a predictive component of diseases, impacting the improvement of indicators of production, productivity, and hospital quality.

Health professionals must have access to and are encouraged to seek improvements related to the use of technologies in patient care, as these tools provide support for more effective care.

This study was conducted in only one hospital, and there is a need for more comprehensive studies with larger cohorts where diverse populations can be compared so that the evidence generated is presented more robustly.

EFETIVIDADE DE UM ALGORITMO PARA IDENTIFICAR PRECOCEMENTE A DETERIORAÇÃO CLÍNICA EM UNIDADES DE INTERNAÇÃO ADULTO

RESUMO

Objetivo: Avaliar a efetividade de um algoritmo para identificar precocemente a deterioração clínica em unidades de internação adulto. **Método:** Estudo de coorte retrospectivo, realizado em um hospital filantrópico localizado no norte paranaense. Procedeu-se à análise de tendência de indicadores referentes à produtividade, produção e qualidade. Adotou-se um erro alfa de 5%. **Resultados:** Os indicadores de produção mostraram tendência decrescente na taxa de ocupação, tanto dos leitos destinados a tratamentos eletivos, quanto daqueles reservados para urgência, e tendência crescente no número absoluto de internações e número de pacientes dia. Nos indicadores de produtividade, observou-se tendência estacionária no índice de renovação de leitos. Em relação à qualidade, verificou-se a predominância da tendência crescente em todas as taxas (infecção, sepse e mortalidade). **Conclusão**: Os resultados demonstraram que o algoritmo foi efetivo, visto que houve melhora nos indicadores de produção, que mostraram tendência decrescente na taxa de ocupação, tanto nos leitos eletivos, quanto nos de urgência; e dos indicadores de produtividade, onde observou-se tendência estacionária no índice de renovação de leitos.

Palavras-chave: Deterioração clínica. Unidades de internação. Indicadores de serviços.

EFECTIVIDAD DE UN ALGORITMO PARA IDENTIFICAR PRECOZMENTE EL DETERIORO CLÍNICO EN UNIDADES DE INTERNACIÓN ADULTA

RESUMEN

Objetivo: evaluar la efectividad de un algoritmo para identificar precozmente el deterioro clínico en unidades de internación adulta. **Método**: estudio de cohorte retrospectivo, realizado en un hospital filantrópico ubicado en el norte de Paraná/Brasil. Se procedió al análisis de indicadores de tendencia referentes a la productividad, producción y calidad. Se adoptó un error alfa del 5%. **Resultados:** los indicadores de producción mostraron tendencia decreciente en la tasa de ocupación, tanto de las camas destinadas a tratamientos electivos, como de aquellos reservados para urgencia, y tendencia creciente en el número absoluto de internaciones y número de pacientes/día. En los indicadores de productividad, se observó tendencia estacionaria en el índice de renovación de camas. En cuanto a la calidad, se observó un predominio de la tendencia creciente en todas las tasas (infección, sepsis y mortalidad). **Conclusión:** los resultados demostraron que el algoritmo fue efectivo, ya que hubo mejora en los indicadores de producción, que señalaron tendencia decreciente en la tasa de ocupación, tanto en las camas electivas, como en los de urgencia; y de los indicadores de productividad, donde se observó tendencia estacionaria en el índice de renovación de camas.

Palabras clave Deterioro clínico. Unidades de internación. Indicadores de servicios.

REFERENCES

1. Lavoie P, Pepin J, Alderson M. Defining patient deterioration through acute care and intensive care nurses' perspectives. Nurs Crit Care. 2016;21:68-77. doi: https://doi.org/10.1111/nicc.12114
2. Morgan RJM, Williams F, Wright MM. An Early Warning Scoring System for detecting developing critical illness. Clin Intensive Care. 1997;8(2):100. Available from: https://www.scienceopen.com/document?vid=28251d22-8476-40a6-916d-1a34796816e4
3. Gondim ES, Gomes EB, Matos JHF, Pinto SL, Oliveira CJ, Parente AMPG. Technologies used by nursing to predict clinical deterioration in hospitalized adults: a scoping review. Rev. Bras. Enferm. 2022;75(5):e20210570. doi: https://doi.org/10.1590/0034-7167-2021-0570
4. Subbe CP, Kruger M, Rutherford P, Gemmel L. Validation of a modified early warning score in medical admissions. QJM. 2001;94(10):521-26. Available from: http://qjmed.oxfordjournals.org/content/94/10/521.long
5. Baker KF, Hanrath AT, Schim van der Loeff I, Kay LJ, Back J, Duncan CJ. National Early Warning Score 2 (NEWS2) to identify inpatient COVID-19 deterioration: a retrospective analysis. Clin Med, 2021;21(2):84-89. doi: https://doi.org/10.7861/clinmed.2020-0688
6. Zhu Y, Chiu YD, Villar SS, Brand JW, Patteril MV, Morrice DJ, Clayton J, Mackay JH. Dynamic individual vital sign trajectory early warning score (DyniEWS) versus snapshot national early warning score (NEWS) for predicting postoperative deterioration. Resuscitation. 2020; 57:176-184. doi: https://doi.org/10.1016/j.resuscitation.2020.10.037
7. Nascimento JSG, Macedo GO, Borges GB. Poder preditivo de uma escala de alerta precoce para deterioração clínica de pacientes críticos. Rev. Enferm. UFSM. 2020;10(e5). doi: https://doi.org/10.5902/2179769238300
8. Cipriano ESV, Salgado BS, Oliveira MS, Aguiar BGC. Implantação do Score de deterioração clínica (MEWS) em um hospital provado da cidade do Rio de Janeiro e seus respectivos resultados. Enferm. Brasil. 2018;17(1):34-42. Available from: https://portalatlanticaeditora.com.br/index.php/enfermagembrasil/article/view/2241/344
9. Neumann VSR, Silva RFA, Roso I. Elaboração de algoritmo para a escolha do banho do paciente coronariopata. Glob Acad Nurs. 2021;2(Spe.3):e161. doi: https://doi.org/10.5935/2675-5602.20200161
10. Alves TF, Tourinho FSV, Andrade SR, Reisdorfer N, Fermo VC. Regulamentação das tecnologias em saúde no Brasil: uma pesquisa documental. Cienc Cuid Saúde. 2022;200. doi: https://doi.org/10.4025/ciencuidsaude.v20i0.57685
11. Von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche

PC, Vandenbroucke JP; STROBE Initiative. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. J Clin Epidemiol. 2008;61(4):344-9. doi: https://doi.org/10.1016/j.jclinepi.2007.11.008

12. Prytherch DR, Smith GB, Schmidt PE, Featherstone PE. ViEWS—Towards a national early warning score for detecting adult inpatient deterioration. Resuscitation. 2010; 81. doi: https://doi.org/10.1016/j.resuscitation.2010.04.014

13. Scherer JS, Pereira JS, Debastiane MS, Bica CG. Beyond technology: Can artificial intelligence support clinical decisions in the prediction of sepsis?. Rev. Bras. Enferm. 2022;75(5):e20210586. doi: https://doi.org/10.1590/0034-7167-2021-0586

14. Rede Interagencial de Informação para a Saúde (RIPSA). Indicadores e dados básicos para a saúde no Brasil (IDB): Conceitos e critérios. 2017. Available from: http://www.ripsa.org.br/vhl/indicadores-e-dados-basicos-para-a-saude-no-brasil idb/conceitos-e-criterios/

15. Tavera CAR, Ortiz JH, Khalaf OI, Ríos AP. Business Intelligence: Evolução dos Negócios após a Indústria 4.0. Sustentabilidade. 2021;13:10026. doi: https://doi.org/10.3390/su131810026

16. Montenegro SMSL, Miranda CH. Evaluation of the performance of the modified early warning score in a Brazilian public hospital. Rev Bras Enferm. 2019;72(6):1428-34. doi: https://doi.org/10.1590/0034-7167-2017-0537

17. Wu CL, Kuo CT, Shih SJ, Chen JC, Lo YC, Yu HH, Huang MD, Sheu WH, Liu SA. Implementation of an Electronic National Early Warning System to Decrease Clinical Deterioration in Hospitalized Patients at a Tertiary Medical Center. Int J Environ Res Public Health. 2021;18(9):4550. doi: https://doi.org/10.3390/ijerph18094550

18. Goh KH, Wang L, Yeow AYK, Poh H, Li K, Yeow JJL, Tan GYH. Artificial intelligence in sepsis early prediction and diagnosis using unstructured data in healthcare. Nat Commun. 2021;12(1):711. doi: https://doi.org/10.1038/s41467-021-20910-4

19. Silva JPT. Análise da eficiência de hospitais regionais em um estado do Nordeste. Saúde debate. 2019; 43(120). doi: https://doi.org/10.1590/0103-1104201912006

20. Botega LA, Andrade MV, Guedes GR. Perfil dos hospitais gerais do Sistema Único de Saúde. Rev. Saúde Públic. 2020;54(81). doi: https://doi.org/10.11606/s1518-8787.2020054001982

21. Lang A, Simmonds M, Pinchin J, Sharples S, Dunn L, Clarke S, Bennett O, Wood S, Swinscoe C. The Impact of an Electronic Patient Bedside Observation and Handover System on Clinical Practice: Mixed-Methods Evaluation. JMIR Med Inform. 2019;7(1):e11678. doi: https://doi.org/10.2196/11678

22. Gerry S, Bonnici T, Birks J, Kirtley S, Virdee PS, Watkinson PJ, Collins GS. Early warning scores for detecting deterioration in adult hospital patients: systematic review and critical appraisal of methodology. BMJ. 2020;369:m1501. doi: https://doi.org/10.1136/bmj.m1501

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