ESTIMA
Brazilian Journal of Enterostomal Therapy

REVIEW ARTICLE
https://doi.org/10.30886/estima.v20.1252_IN

IMPLEMENTED TECHNOLOGIES FOR PRESSURE INJURY PREVENTION IN THE HOSPITAL CONTEXT: INTEGRATIVE REVIEW

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ABSTRACT

The present study aimed to analyze in the literature the technologies implemented to prevent pressure injuries in the context of hospital care. This is an integrative literature review carried out from October to December 2021, in the databases: Virtual Health Library; MEDLINE via PubMed; Scopus; Web of Science; Embase and Cochrane Library, and 192 articles were included and 179 excluded. The final sample consisted of 13 articles, that met the eligibility criteria and answered the objective and research question. The main technologies used were air mattresses, permanent education mediated by e-learning, a computer system that facilitates the identification of risk factors, a light signal system for activating the team, a computer system for monitoring tissue pressure, a software for implementing computerized guidelines, an informative catalog, clinical guidelines, and a virtual learning environment. These technologies have shown positive results, however, as identified in the analysis, most studies deal with descriptive research designs with low inference power, which opens space for experimental research to prove the real benefits of technologies more accurately for pressure injury prevention.

DESCRIPTORS: Pressure ulcer. Biomedical technology. Health centers. Hospital units. Enterostomal therapy.

TECNOLOGIAS EM SAÚDE IMPLEMENTADAS PARA PREVENÇÃO DE LESÃO POR PRESSÃO NO CONTEXTO HOSPITALAR: REVISÃO INTEGRATIVA

RESUMO

O presente estudo teve como objetivo analisar na literatura as tecnologias implementadas para prevenção de lesão por pressão no contexto da assistência hospitalar. Trata-se de uma revisão integrativa da literatura realizada no período de outubro a dezembro de 2021, nos bancos de dados: Biblioteca Virtual de Saúde, MEDLINE via PubMed, Scopus, Web of Science, Embase e Cochrane Library. Foram incluídos 192 artigos e excluídos 179. A amostra final foi composta de 13 artigos, que atenderam aos critérios de elegibilidade e responderam ao objetivo e à questão de pesquisa. Evidenciou-se que as principais tecnologias utilizadas foram colchões de ar, educação permanente mediada por *e-learning*, sistema computacional que facilita a identificação de fatores de risco, sistema de sinal luminoso para acionamento da equipe, sistema computacional para monitoramento da pressão tecidual, *software* para implementação de diretriz informatizada, catálogo informativo, diretrizes clínicas e ambiente

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Section Editor: Manuela M. Figueirêdo Coelho
Received: May 10, 2022 | Accepted: Aug. 25, 2022
How to cite: Araújo EB; Bezerra SMG; Machado JS; Silva IMB; Ferreira LFO; Lira JAC; Santana RS (2022) Implemented technologies for pressure injury prevention in the hospital context: integrative review. ESTIMA, Braz. J. Enterostomal Ther., 20: e2622. https://doi.org/10.30886/estima.v20.1252_IN

virtual de aprendizagem. Essas tecnologias demonstraram resultados positivos, no entanto, majoritariamente, os estudos tratam de desenhos de pesquisa descritivos com baixo poder de inferência, o que aponta para uma lacuna de pesquisas experimentais a fim de comprovar com maior exatidão os reais benefícios das tecnologias para a prevenção de lesão por pressão.

DESCRITORES: Lesão por pressão. Tecnologia biomédica. Centros de saúde. Unidades hospitalares. Estomaterapia.

TECNOLOGÍAS SANITARIAS IMPLEMENTADAS PARA LA PREVENCIÓN DE LA LESIÓN POR PRESIÓN EN EL CONTEXTO HOSPITALARIO: REVISIÓN INTEGRATIVA

RESUMEN

El presente estudio tuvo como objetivo analizar en la literatura las tecnologías implementadas para la prevención de lesiones por presión en el contexto de la atención hospitalaria. Esta es una revisión integrativa de la literatura realizada de octubre a diciembre de 2021, en las bases de datos: Biblioteca Virtual en Salud; Medline vía Pubmed; Scopus; Web of Science; Embase e Cochrane Library. Se incluyeron 192 artículos y se excluyeron 179. La muestra final estuvo conformada por 13 artículos que cumplieron con los criterios de elegibilidad y respondieron el objetivo y pregunta de investigación, se evidenció que las principales tecnologías utilizadas fueron colchones de aire, educación permanente mediada por e-learning, una computadora sistema que facilita la identificación de factores de riesgo, un sistema de señalización luminosa para la activación del equipo, un sistema informático de monitorización de la presión tisular, un software para la implementación de guías informáticas, un catálogo informativo, guías clínicas y un Entorno Virtual de Aprendizaje. Estas tecnologías han mostrado resultados positivos, sin embargo, como identificado en el análisis, la mayoría de los estudios se ocupan de diseños de investigación descriptivos con bajo poder de inferencia, lo que abre espacio para la investigación experimental para probar con mayor precisión los beneficios reales de las tecnologías para la prevención de lesiones por presión.

DESCRIPTORES: Úlcera por presión. Tecnología biomédica. Centros de salud. Unidades hospitalarias. Estomaterapia.

INTRODUCTION

Pressure injury (PI) is defined as localized damage to the underlying skin, tissue or structure, usually over a superficial or deep bony prominence, of ischemic etiology caused by prolonged pressure combined with shear, which can result in tissue necrosis[1].

This damage can occur in patients hospitalized in any hospital treatment unit and outside the hospital context as well, in cases of patients with paraplegia using a wheelchair, for example[2,3], however, it is more common in contexts of long-term hospitalizations, especially in intensive care units (ICU), where patient mobilization, in many cases, is impaired because of the clinical condition. PI has a high incidence in the world and in Brazil; studies found that the incidence in the world is between 14.3 and 18.7%, and in Brazil, between 23.1 and 59.5%[4].

Furthermore, in Brazil, there is no national or regional system that gathers information on epidemiological indicators in relation to PI indices, which limits a more accurate knowledge of the impacts on health services[5]. In this way, policies and strategies may be incorporated more slowly or not at all.

Likewise, it is worth mentioning that the PI is an indicator for measuring the quality of the service, as this event is considered to be avoidable, in most cases. This harm to the patient causes, in addition to physical and psychological changes, a high risk for complications and higher costs for health institutions[6].

With the advances in science and technology, the need to have technological tools in care is indisputable to provide higher quality care. Health technologies are defined as any activity or knowledge used to promote health. In this sense, it can refer to equipment for diagnosis or treatment, medicines, programs, systems and processes in promoting healthcare[7,8].

Nursing care is essential, especially in the prevention of PI, and measures should guide the care practices of the team and contribute to reducing the incidence of injuries and improving service quality indicators[9].

With technological advances and given the need to gather relevant information to promote health care, it is imperative to synthesize knowledge about the main technologies used in the prevention of PI, due to the scarcity of research for this purpose. In addition, it is noteworthy that such injuries are an event that must be prevented, in view of the negative repercussions both on the patient and on the health service. Given the above, this study aimed to analyze, in the literature, the technologies implemented to prevent PI in the context of hospital care.

METHODS

This is an integrative literature review, developed in six stages:

- Formulation of the research question;
- Sampling;
- Data extraction;
- Critical evaluation;
- Analysis and synthesis of results;
- Knowledge synthesis[10].

Through this, the research question of the study was constructed based on the PICo strategy (P: problem or target population; I: intervention or phenomenon of interest; Co: context), as shown in Table 1.

Table 1. Formulation of the research question. Teresina, Piauí, Brasil, 2022.

ACRONYM	DEFINITION	RELATED TERM
P	Patient, population or problem	Pressure injury prevention
I	Intervention or indicator (phenomenon of interest)	Health technologies
Co	Study context	Hospital unit

Source: adapted from Joana Briggs Institute11[11].

Thus, the following research question was elaborated: what are the health technologies implemented to prevent PI in the hospital context?

The following inclusion criteria were defined: primary studies related to health technologies implemented for the prevention of PI in the hospital context, without delimiting languages or time frame. The exclusion criteria were: studies from expert opinions, editorials, term papers, monographs, dissertations and theses.

It is known that an integrative review of the comprehensive literature should include as many banks and databases as possible for the retrieval of studies with methodological quality and that respond to the research question and the study objectives. Thus, the *Biblioteca Virtual de Saúde (BVS)* was used, retrieving studies from the Scientific Electronic Library Online (SciELO) and the Latin American and Caribbean Health Sciences Literature (LILACS) bibliometric index, in addition to the MEDLINE databases via PubMed, Scopus , Web of Science, Embase and Cochrane Library, which include studies in the health sciences. All databases and repositories were accessed through the journal portal of the Coordination for the Improvement of Higher Education Personnel (*Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - CAPES*).

For the construction of the search expression, the controlled and uncontrolled vocabularies of the respective database and the cited databases were accessed and combinations with the Boolean operators OR and AND were performed. The syntax of combinations and final search expressions is shown in Table 2. The final search of the BVS took place only with the combinations of the acronyms P and I, because of the restriction and non-recovery of articles when the three acronyms of the PICo strategy are combined.

Table 2. Syntaxes used in banks and repositories to retrieve articles. Teresina, Piauí, Brasil, 2022.

BVS SEARCH EXPRESSION
((mh:("Lesão por Pressão")) OR ("Escara de Decúbito") OR ("Úlcera de Decúbito") OR ("Úlcera de Pressão") OR (Úlcera por Pressão) OR (Úlceras por Pressão)) AND ((mh:("Centros de Saúde")) OR ("Unidade de Saúde") OR (mh:("Unidades Hospitalares")) OR ("Unidade Hospitalar de Saúde Pública")) AND (("Tecnologia e Aplicativos de Software") OR ("Tecnologias e Aplicativos de Software") OR ("Tecnologia Aplicada à Assistência à Saúde") OR (mh:("Tecnologia Biomédica")) OR ("Tecnologia em Saúde") OR ("Tecnologia Médica") OR ("Tecnologias em Saúde") OR (mh:("Tecnologia da Informação")) OR ("Tecnologias da Informação e Comunicação") OR ("Tecnologias da Informação e Comunicações"))
MEDLINE SEARCH EXPRESSION
(((((("pressure ulcer"[MeSH Terms])) OR ("pressure ulcers"[All Fields])) OR ("bedsore"[All Fields])) OR ("pressure sore"[All Fields])) OR ("decubitus ulcer"[All Fields])) AND ((((((((("information dissemination"[MeSH Terms]) OR ("ehealth strategies"[All Fields])) OR ("internet"[MeSH Terms])) OR ("world wide web"[All Fields])) OR ("cyberspace"[All Fields]))) OR ("biomedical technology"[MeSH Terms])) OR ("biomedical technologies"[All Fields])) OR ("information technology"[MeSH Terms])) OR ("information technologies"[All Fields]))) AND (("hospitals"[MeSH Terms]) OR ("hospital"[All Fields]))
WEB OF SCIENCE SEARCH EXPRESSION
(TS= ("Pressure Ulcer") OR TS= ("Pressure Ulcers") OR TS=(Bedsore) OR TS= ("Pressure Sore") OR TS= ("Decubitus Ulcer")) AND (TS= ("Information Dissemination") OR TS= ("eHealth Strategies") OR TS= (Internet) AND TS= ("World Wide Web") OR TS= ("Biomedical Technology") OR TS= ("Biomedical Technologies") OR TS= ("Information Technology") OR TS= ("Information Technologies")) AND (TS= (Hospitals) OR TS= (Hospital))
SCOPUS SEARCH EXPRESSION
((TITLE-ABS-KEY("Pressure Ulcer") OR TITLE-ABS-KEY("Pressure Ulcers") OR TITLE-ABS-KEY(Bedsore) OR TITLE-ABS-KEY("Pressure Sore") OR TITLE-ABS-KEY("Decubitus Ulcer"))) AND ((TITLE-ABS-KEY("Information Dissemination") OR TITLE-ABS-KEY("eHealth Strategies") OR TITLE-ABS-KEY(Internet) OR TITLE-ABS-KEY("World Wide Web") OR TITLE-ABS-KEY("Biomedical Technology") OR TITLE-ABS-KEY("Biomedical Technologies") OR TITLE-ABS-KEY("Information Technology") OR TITLE-ABS-KEY("Information Technologies"))) AND ((TITLE-ABS-KEY(Hospitals) OR TITLE-ABS-KEY(Hospital)))
EMBASE SEARCH EXPRESSION
('decubitus'/mj OR 'bedsore' OR 'decubital ulcer' OR 'decubitus ulcer' OR 'pressure injury' OR 'pressure sore' OR 'pressure ulcer') AND ('information dissemination'/mj OR 'dissemination of information' OR 'internet'/mj OR 'internet connection' OR 'world wide web' OR 'medical technology'/mj OR 'bio-medical technology' OR 'biomedical technology') AND ('hospital'/mj OR 'environment, hospital' OR 'hospital' OR 'hospital environment' OR 'hospital establishment' OR 'regional hospital' OR 'state hospital')
COCHRANE SEARCH EXPRESSION
(("Pressure Ulcer") OR ("Pressure Ulcers") OR (Bedsore) OR ("Pressure Sore") OR ("Decubitus Ulcer")) AND (("Information Dissemination") OR ("eHealth Strategies") OR (Internet) OR ("World Wide Web") OR (Cyberspace) OR ("Biomedical Technology") OR ("Biomedical Technologies") OR ("Information Technology") OR ("Information Technologies")) AND ((Hospitals) OR (Hospital))

BVS: Biblioteca Virtual da Saúde. Fonte: elaboração própria. Source: own elaboration.

In all, 192 articles were retrieved. To assist in the screening and selection of studies, the application rayyan.qcri.org was used, which detected a total of 71 duplicate articles.

Thus, 121 articles were selected for the first stage of selection (reading the title and abstract). After peer review of title and abstract, 59 studies were excluded because they did not agree with the study objective or the research question. Thus, 62 articles remained for the second stage of selection.

After reading the studies in full, 49 articles were excluded because they did not meet the eligibility criteria, leaving 13 articles for the sample composition. The selection steps are described in detail in Figure 1. It is noteworthy that the selection process was carried out by peers, and there was no need to consult a third evaluator.

The extraction of data from eligible studies took place using a data collection instrument built by the research authors. This instrument includes the following information: author(s), journal, year of publication, study location, objective, technology implemented, outcome, design and level of evidence.

The level of evidence classification followed the Melny and Fineout-Overholt framework[12]:

- Level I: systematic review or meta-analysis of randomized controlled trials;
- Level II: well-designed randomized controlled clinical trials;

• Level III: well-designed clinical trials without randomization;
• Level IV: well-designed cross-sectional and case-control studies;
• Level V: systematic review of descriptive and qualitative studies;
• Level VI: descriptive or qualitative study;
• Level VII: opinion of authorities and/or reports.

Data were analyzed descriptively, using the criteria of semantic similarity, to guide the synthesis of results and the construction of the following thematic categories:

• Health technologies implemented to the team in the PI prevention process;
• Health technologies implemented to the user in the PI prevention process.

The reference adopted for classifying technologies was the one proposed by Merhy[13], in which the author divides technologies into three types: light, light-hard and hard. Light technologies are related to bonding, welcoming and autonomy of the subject; the light-hard ones refer to structured knowledge that operate changes in work processes; and the hard ones relate to equipment, devices, norms and organizational structures.

RESULTS

As shown in the prism flowchart (Figure 1), a total of 13 studies were retrieved, which fit the protocol of the integrative literature review, that is, they answered the research question and met the objectives and eligibility criteria.

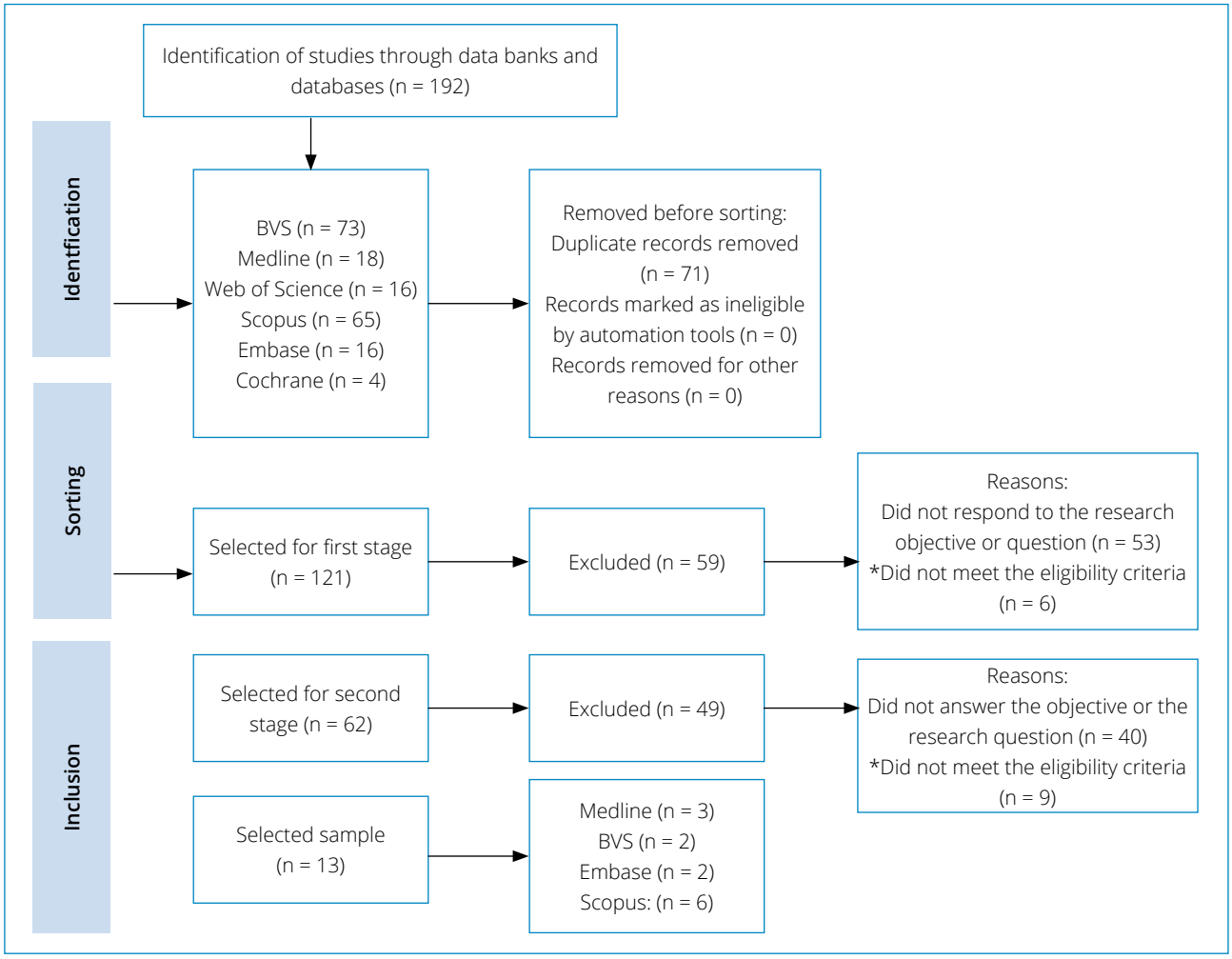

Figure 1. Prism Flowchart. Teresina, Piauí, Brasil, 2022.
Source: adapted from Page et al..[14].

The years with the highest number of publications were 2008 and 2020 (n = 2), with the journal *Advances in Skin & Wound Care* having the highest number of publications (n = 2), and the country with the highest number of productions was the United States of America (n = 7).

Table 3 provides detailed information about the publications. Regarding the research design, it was observed that seven were descriptive studies, and the most present technologies were hard technologies (n = 9).

Table 3. Description of articles included in the integrative review by title, authors, journal and country. Teresina, Piauí, Brasil, 2022.

N	Title	Authors	Year	Journal	Country
1	"A computerised guideline for pressure ulcer prevention"	Quaglini et al.[15]	2000	*International Journal of Medics Informatics*	USA
2	"Quality of care for hospitalized Medicare patients at risk for pressure ulcers"	Lyder et al.[16]	2001	*Archives of Internal Medicine*	USA
3	"Comparing the effectiveness of a specialized alternating air pressure mattress replacement system and an air-fluidized integrated bed in the management of post-operative flap patients: a randomized controlled pilot study"	Finnegan et al.[17]	2008	*Journal of Tissue Viability*	USA
4	"Improving practice: efforts to reduce occipital pressure ulcers"	Jacobson et al.[18]	2008	*Journal of Nursing Care Quality*	USA
5	"Multisite Web-based training in using the Braden Scale to predict pressure sore risk"	Morris e Maklebust[19]	2008	*Advances in Skin & Wound Care*	USA
6	"Staff response time to call lights and unit-acquired pressure ulcer rates in adult in-patient acute care units"	Tzeng et al.[20]	2013	*Contemporary Nurse*	Taiwan
7	"A framework of quality improvement interventions to implement evidence-based practices for pressure ulcer prevention"	Padula et al.[21]	2014	*Advances in Skin & Wound Care*	USA
8	"Are evidence-based practices associated with effective prevention of hospital-acquired pressure ulcers in US academic medical centers?"	Padula et al.[22]	2016	*Medical Care*	USA
9	"Evaluation of a multifactorial approach to reduce the prevalence of pressure injuries in regional Australian acute inpatient care settings"	Smith et al.[23]	2017	*International Wound Journal*	Australia
10	"Static overlays for pressure ulcer prevention: a hospital-based health technology assessment"	Horup et al.[24]	2020	*British Journal of Nursing*	Denmark
11	"A smart IoT system for detecting the position of a lying person using a novel textile pressure sensor"	Hudec et al.[25]	2020	*Journal of Sensors*	Slovakia
12	"Algoritmo de prevenção e tratamento de úlcera por pressão"	Pott et al.[26]	2013	*Cogitare Enfermagem*	Brazil
13	"Educational intervention to assess the knowledge of intensive care nurses about pressure injury"	Araújo et al.[27]	2019	*Rev Rene*	Brazil

Source: own elaboration.

According to Table 4, it was evidenced that the main technologies implemented were: air mattresses, permanent education mediated by e-learning, computer system to prevent PI, light signal system to activate the team, computer system to monitor the tissue pressure, software for computerized guideline implementation, informative catalog, clinical guidelines and virtual learning environment.

Table 4. Description of articles according to objective, type of technology implemented, design/level of evidence and main results. Teresina, Piauí, Brasil, 2022.

Authors	Objective	Technology implemented	Design/ level of evidence	Type of technology	Main results
Quaglini et al.[15]	To compare cost and effectiveness of two types of air mattress.	Air mattress with alternating pressure and mattress with fluidized air pressure.	Randomized clinical trial/ level II.	Hard technology	Alternating pressure therapy demonstrated a statistically significant result ($p < 0.05$) in terms of cost, satisfaction and comfort when compared to fluidized air pressure therapy.
Lyder et al.[16]	Investigate the properties and consequences of using static overlays to prevent pressure injuries.	Mattress with high density viscoelastic foam and mattress with polyurethane thermoplastic.	Observational study/level VI.	Hard technology	Não houve diferença significativa entre as duas tecnologias testadas. A equipe considerou que as sobreposições estatísticas dificultam os cuidados com a higienização.
Finnegan et al.[17]	To compare changes in pressure injury prevalence between 2008 and 2014 in relation to staff behavior.	Permanent education mediated by e-learning.	Cross-sectional study/level VI	Hard technology	Through the training carried out, the measures implemented by the team, such as the documentation of risk assessment and the repositioning of pressure relief equipment, provided a 15.7% reduction in the prevalence of pressure injuries.
Jacobson et al.[18]	Profile and assess care processes for medicare patients at risk of developing pressure ulcers using the Quality indicator system pressure ulcer prediction	*Quality indicator system pressure ulcer prediction.*	Cohort study/ level IV.	Hard technology	The system enabled an audit process capable of measuring which measures the team implemented and the impact of those measures on pressure injury prevention.
Morris e Maklebust[19]	Examine the response time of the nursing staff to respond to the light signal and carry out preventive measures to reduce the incidence of pressure injuries.	Light signal activated by the patient or family members to receive care by the nursing team.	Descriptive study/level VI.	Hard technology	Shorter response time of the team to the light call showed a significant correlation in relation to the lower percentage of pressure injuries.
Tzeng et al.[20]	To describe the development of a system for monitoring the pressure of a bedridden patient.	Intelligent tissue pressure monitoring system.	Descriptive study/level VI.	Hard technology	The system proved to be effective for measuring tissue pressure and classifying the best positions to provide less pressure, in addition to generating indications for the nursing team to change decubitus position.

continue...

Table 4. Continuation...

Authors	Objective	Technology implemented	Design/ level of evidence	Type of technology	Main results
Padula et al.[21]	To describe the implementation of a computerized guideline for pressure injury prevention.	*Software for implementing a computerized guideline.*	Descriptive study/level VI.	Hard technology	The software allowed the organization of reports, which facilitated better care planning by the nursing team, in addition to having an educational interface, which was well evaluated by users.
Padula et al.[22]	To describe a framework aligned with evidence-based practice for the development of a set of measures to prevent pressure injuries in the hospital context.	Informative catalogue.	Descriptive study/level VI.	Light-hard technology.	The authors reinforce that the framework can be replicated in different contexts when it is intended to implement organizational changes to apply new practices, such as the adoption of protocols, such as the protocol of the National Pressure Ulcer Advisory Panel .
Smith et al.[23]	Assess the longitudinal impact of medicare and medicaid service policy and adoption of improved quality of care.	Medicare and Medicaid Operational Standard.	Descriptive study/level VI.	Hard technology	Organizational changes can promote the improvement of the quality of care provided by the nursing team, through the implementation of stricter rules. Thus, a statistically positive result was obtained in reducing the incidence of pressure injuries.
Horup et al.[24]	To describe the implementation of evidence-based guidelines of care for pressure injury prevention in cervical collar patients.	Evidence-based clinical guidelines.	Descriptive study/level VI.	Light-hard technology.	After the implementation of care guidelines for the prevention of pressure injuries in patients using cervical collars, a sharp decline in the incidence of pressure injuries was observed.
Hudec et al.[25]	To assess the effect of a web-based training module on the Braden scale on nurses' knowledge of pressure injury risk assessment and prevention.	Virtual learning environment.	Experimental study/level III.	Hard technology	After this training, the nurses correctly assessed 82.6% of the evaluation time, however the assessment of high risk for the development of pressure injuries was linked to severe cases. There was adequate knowledge about preventive measures, but without significant correlation with the numerical data assigned to the scale.

continue...

Table 4. Continuation...

Authors	Objective	Technology implemented	Design/ level of evidence	Type of technology	Main results
Pott et al.[26]	To describe the development of an algorithm for the prevention and treatment of pressure ulcers in a university hospital in Curitiba, Paraná.	Algorithm.	Descriptive study/level VI.	Light-hard technology.	It was identified that the instrument provides a broad view of the entire process, facilitating the management of nursing care and ensuring evidence-based practice.
Araújo et al.[27]	Educational intervention to assess the knowledge of intensive care nurses about pressure injuries.	Permanent education mediated by e-learning.	Cohort study/ level IV.	Hard technology	After the educational intervention, there was an increase of 3% in the average of correct answers in the post-test group.

Source: own elaboration.

DISCUSSION

Health technologies implemented to the nursing team in the pressure injury prevention process

Several technologies were developed between 2000 and 2020, which are related to the training of professionals or the implementation of systems and software aimed at applying strategies and standards in the work process of care teams in the hospital context.

As for the changes in practices that can be developed by the team, some simple and low-cost technologies refer to the training processes carried out through digital platforms, which save expenses by not using the physical structure or requiring the displacement of professionals. In this context, a permanent education process mediated by e-learning was implemented in Australia to train professionals on measures to prevent PI, which proved to be efficient, this fact being proven by the reduction of the prevalence of PI after an audit process in the district of health Hunter New England[23].

E-learning can be a powerful educational tool for the process of qualification and continuing education, mainly because it contributes to raising awareness among professionals in the implementation of preventive measures and supporting process changes. This result corroborates the findings of Murray[28] and Law[29], who reported that continuing education programs can reduce the number and severity of PI, through the implementation of preventive measures addressed in an education process mediated by e-learning.

In this same perspective of continuing education, training was carried out on the use of Braden scales by nurses in three large hospitals in the United States of America. The educational intervention was based on web training and brought positive results in terms of the effect caused by the intervention on the knowledge of these professional nurses, demonstrated by the indicators of correct answers in the assessment of patients regarding the risk of developing PI[19].

The study by Araújo et al.[27] converges with the same findings presented above. The authors carried out a longitudinal study to compare the effects of educational intervention on PI, before and after the implementation of the qualification course. They observed that the post-test participants had higher mean scores on prevention of PI than the pre-test group, which indicates the importance of including technologies in the continuing education process.

Other measures are of paramount importance for the prevention of PI in the hospital environment, especially in the ICU, where the risk of developing this health problem can be increased by the clinical conditions of the assisted patients. Thus, other studies point to effective measures related to the implementation of protocols, standards and systems that aim to organize the work process concerning the measurement of the risk of developing PI and the preventive measures that must be implemented by the care team.[15,16,18,21,22].

In this context, an operational system was developed in the United States of America to assist in the management and auditing of care for patients at risk of developing PI in all medicare hospitals. This system, called Quality Indicator System Pressure Ulcer Prediction, allowed an audit to verify what types of preventive measures were adopted by the assistance team and the impacts generated in the prevention of PI[16].

Still considering systems and software, a system was also created in the United States of America to implement a clinical guideline for the prevention of PI linked to the patient's electronic medical record. This system allows the generation of reports and verification of the measures implemented by the team. In addition, it provides an educational process based on simulated clinical cases that guide the conduct that professionals must take to implement preventive measures according to each case, proving to be an important tool in the continuing education process. This system was well evaluated by the nurses who used it, as it facilitated the registration process and made decision-making safer and more assertive[15].

In the same context of the measures applied by the management of the process of institutionalization of guidelines, other studies corroborate this action. A study by Padula et al.[21] implemented an informative catalog built on the precepts of evidence-based practice related to a set of measures to prevent PI. According to the authors, this technology should be used in several services, being a way to institutionalize measures supported by the scientific literature.

In the study of Jacobson et al.[18], there is a reinforcement of the importance of adopting evidence-based practices to establish clinical guidelines related to the prevention of PI. In this work, the authors inserted a clinical protocol for the prevention of PI in patients using a cervical collar and evaluated that there was a reduction in the incidence of PI after the guidelines were established.

Still on the implementation of guidelines, another study corroborates these results, regarding the importance of using instruments to guide the performance of the nursing team in the PI prevention process. Pott et al.[26] developed an algorithm based on the Braden scale to guide the process of assessment and conduct of nursing professionals with patients at risk or with PI already installed. They observed that this algorithm provided improved care management. Thus, the importance of such tools for evidence-based practice and the consequent qualification of care is emphasized.

Finally, the implementation of stricter rules aimed at complying with PI prevention measures can be a simple and low-cost technology with positive effects on indicators. In the study carried out by Padula et al.[22], in medicare hospitals in the United States of America, it was evidenced that strict rules such as cuts in financial transfers to institutions due to non-application of PI preventive measures resulted in a reduction in the incidence and improvement of this indicator.

The aforementioned technologies can be incorporated into the clinical practice of health services, mainly in countries like Brazil, which still present challenges for the prevention of PI, evidenced by the high incidence rates of this problem, as mentioned above. In this sense, the incorporation of some of these technologies can contribute to the improvement of this indicator, in view of the practicality and systematization of the processes resulting from the incorporation of these technologies.

Health technologies implemented to the user in the pressure injury prevention process

The main preventive measures implemented in the user generally refer to pressure relief. This can be mediated by changing the position and/or using overlays to ease the pressure on the tissue. In addition, some comparative studies were carried out to measure the effect of these interventions and describe the findings regarding the use of technologies associated with the management of the care team regarding the change in the decubitus position.[15-17,20,24].

One of the main measures for the prevention of PI is related to the contraposition of its pathophysiological mechanism, that is, the relief of pressure. This relief can be aided by hard technologies, such as the air mattress, or by light-hard technologies, in the case of systematized knowledge and the action generated by changing the patient's position. However, the two technologies added together increase even more the effectiveness of the intervention for the prevention[15,16].

As for the types of mattress, there are two types most used in clinical practice, however it is necessary to highlight the most effective type of technology. Thus, a randomized controlled clinical trial compared two types of mattress (air mattress with alternating pressure and air mattress with fluidized air), evidencing the greater effectiveness of the air mattress with alternating pressure[17].

Still on the adjuvant technologies in the P I prevention process, there are static overlaps that provide a degree of tissue protection, although they do not have the best evidence when compared to the dynamic technology of alternating pressure. One study proposed to describe the use and draw a small-scale comparison of two different types of overlay. The first referred to a mattress with high-density viscoelastic foam, and the second, a mattress with polyurethane thermoplastic. After the analysis, it was shown that there were no statistically significant differences. In addition, the team found that reusable static overlays after disinfection make the patient's hygiene process more difficult[24].

A group of researchers created a system capable of measuring pressure levels in different parts of the patient's body and indicating which region is exposed to the greatest degree of pressure, in addition to alerting professionals about the moment to make the change of decubitus and area of increased risk for the development of the lesion. This is still an incipient study, as it has not been tested on a large scale, but presented satisfactory results in the initial tests, which may help professionals even more effectively in the planning and execution of care[16].

Still dealing with preventive measures adopted with patients with the principle of adopting measures to relieve pressure, researchers evaluated the nursing team's response time to the light signal activated by family members or caregivers and the incidence of PI. The authors found that the shorter response time of the nursing team to the light call showed a positive correlation in the result, which may show that more frequent assessments can contribute to better care management and application of PI prevention measures, such as skin assessment and position change[20].

It is worth noting the low amount of evidence on the national scene. This fact may be linked to the very limitation of the method, which does not aim to map all the existing literature (as in the scoping review, which also considers gray literature in the analyses), however, this highlights a gap in knowledge so that new research can be carried out at the national level, such as scoping review, systematic review and experimental studies on the development and application of technologies in the prevention of PI.

CONCLUSION

The study provided knowledge of the main technologies used in the prevention of PI in the hospital environment. Different technologies were evidenced, such as air mattresses, permanent education mediated by e-learning, computer system for PI prevention, light signal system for activating the nursing team, computer system for monitoring tissue pressure, software for the implementation of computerized guidelines , informative catalog, clinical guidelines and virtual learning environment.

These technologies showed positive results, however, as identified in the analysis, most studies design descriptive research, with low power of inference, which points to a gap in knowledge regarding the effectiveness of technologies and the importance of performing experimental studies or even systematic reviews to more accurately prove the real benefits of the technologies presented for the prevention of PI.

Finally, this study is an important tool for the implementation of evidence-based practice by professionals and researchers, considering that the various technologies presented can be incorporated into care protocols in order to improve the quality of service and reduce the incidence of P I. Furthermore, it is expected that this research can instigate new intervention studies based on the technologies documented in this review and the consequent improvement of care and service quality indicators.

AUTHORS' CONTRIBUTION

Substantive scientific and intellectual contributions to the study: Araújo EB and Machado JS; **Conception and design:** Ferreira LFO and Santana RS; **Data collection, analysis and interpretation:** Ferreira LFO and Lira JAC; **Article writing:** Araújo EB and Machado JS; **Critical review:** Ferreira LFO, Santana RS and Bezerra SMG; **Final approval:** Santana RS and Bezerra SMG.

DATA STATEMENT AVAILABILITY

All data from the collection and analysis will be made available upon request.

FUNDING

Not applicable.

ACKNOWLEDGEMENTS

To Prof. Sandra Marina Gonçalves Bezerra for the technical review and mediation for the publication of the study.

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