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Scoping Review Article | *Medicine*

Effectiveness of educational interventions to reduce healthcare- associated infections in adult intensive care units

Efectividad de las intervenciones educativas en la disminución de infecciones asociadas al cuidado de la salud en la unidad de cuidados intensivos para adultos

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Abstract

Healthcare-associated infections (HAIs) represent a serious threat to patients admitted to hospitals and particularly to ICUs, as they contribute to increased mortality, prolonged length of stay and consequently increased healthcare costs. The aim of the present scoping review was to evaluate the effectiveness of educational interventions for the reduction of these infections in the adult ICU. A systematic literature search was conducted from December 2022 to March 2023, making use of official electronic databases such as PubMed, SCOPUS, CINAHL and Cochrane Database of Systematic Reviews; the key terms used for the search were the following: "Healthcare Associated Infections"; "educational interventions"; "intensive care unit" in all possible combinations and making use of the Boolean operators "AND" and "OR"; the application of the PRISMA methodology allowed a final screening of ten[MOU2] (10) studies on which the present review was based. In the selected studies, it was evident that education was essential and should be shared between multidisciplinary care teams, patients, their families, and caregivers. Statistical significance was found in two studies that demonstrated a reduction in HAIs. Despite considerable variation in the duration and type of educational intervention, the importance of establishing continuing education to maintain intervention results.

Resumen

Las infecciones asociadas al cuidado de la salud (IAAS) representan una amenaza para los pacientes que ingresan a hospitales y especialmente a UCI, al contribuir en el aumento de la mortalidad, prolongación de su estancia e incremento en los costos. El objetivo de este trabajo fue evaluar la efectividad de las intervenciones educativas para la reducción de las IAAS en la UCI de adultos. Se realizó búsqueda bibliográfica entre Diciembre 2022 - Marzo 2023 en las bases de datos PubMed, SCOPUS, CINAHL y Cochrane Database of Systematic Reviews. Términos claves usados en todas las combinaciones: “Healthcare Associated Infections”; “educational interventions”; “intensive care unit”. Mediante la metodología PRISMA se obtuvo un resultado de 10 estudios [MOU1]. En ellos se evidenció que la educación es esencial y debe ser compartida entre los equipos de cuidado multidisciplinarios, los pacientes, familias y los cuidadores; además hubo significancia estadística en dos estudios que demostraron una reducción en las IAAS. A pesar de la variación considerable en la duración y el tipo de intervención educativa, se resalta la importancia de establecer la educación continua para mantener los resultados de la intervención y lograr mejoras significativas en los resultados clínicos.

Introduction

Healthcare-associated infections (HAIs), also known as nosocomial or hospital-acquired infections (HAIs), are a risk to any patient receiving care from healthcare workers [1]. Infectious processes acquired while hospitalised or within 72 hours of discharge, although this can be extended to 12 months following discharge [2]. These infections are caused by microorganisms that can be recognised by clinical and/or microbiological manifestations that depend on the pathogen, the site of infection and the condition of the host; in some specific cases, they correlate with surgical procedures such as prosthesis placement [3]. These infections can be primary or secondary, with primary infections being more common, occurring mainly in intensive care units (ICUs) and associated with central venous catheter (CVC) insertion [4].

The complications caused by these infections have multiple consequences for the patient, both in terms of morbidity and future living conditions due to possible disability, in addition to the incalculable social costs due to the impact on the family and work environment. For healthcare systems in particular, they represent a high cost in terms of the care that must be provided due to prolonged hospitalisation, the use of antibiotics as a result of bacterial resistance, diagnostic tools, medical assessments and possible new interventions [5].

Worldwide, 5-10% of patients in countries with advanced health care facilities acquire this type of disease. In the United States, catheter-associated bloodstream infections (CA-BSTIs) were the most common type of external device-associated infection (48.1%) between 1995 and 2001 [6]. On the other hand, between July 2005 and May 2008, Staphylococcus aureus was the most common pathogen associated with serious bloodstream infections [7]. Exact figures on the burden of these infections are not available for Latin America. However, countries such as Brazil, Chile and Mexico are developing research to characterise the problem in order to develop mitigation strategies [6].

In Colombia, according to the report presented by the National Institute of Health for the year 2020, the Adult and Neonatal Intensive Care Units were the services reporting the highest number of such cases [5]. In terms of type of infection, catheter-associated bloodstream infections (CA-BSTI) were the most common (48.1%), followed by mechanical ventilator-associated pneumonia (28.2%) and symptomatic catheter-associated urinary tract infections (CA-UTI) (22.8%) [5]. Given the high number of infections associated with the use of these devices, a number of strategies have been developed to prevent them. Interventions include the creation of plans tailored to the needs of each patient, with daily measurable objectives that engage both service staff and patients, relatives and carers [8]. On the other hand, in 2005, the Institute for Healthcare Improvement (IHI) identified the need for prophylactic measures such as hand hygiene, barrier precautions and chlorhexidine antisepsis [9].

In this context, Fox et al. [10] developed a protocol that included a chlorhexidine gluconate hand hygiene technique, which was disseminated to ICU nurses through a 10-week educational process. They achieved a reduction in bloodstream infections from 60 to 87% over a 12-month period [10]. Despite the protocols developed to reduce the incidence of healthcare-associated infections, research shows that their rates are still high, as are the secondary complications they cause. For this reason, we considered it necessary to carry out an in-depth study of various bibliographical sources on the way in which these protocols are disseminated among the health professionals responsible for these procedures and on the effectiveness of their application as preventive measures to control the development of infections. In view of the above, it was decided to carry out a scoping review study [11], whose aim was to determine the effectiveness of educational interventions in the reduction of HAIs in adult intensive care units.

Methods

Protocol and registration

The study was conducted according to the Preferred Reporting Item Statement for Scoping Reviews (PRISMA-ScR) guidelines [12]. We chose to review and include the protocol, which was validated by the Prospective International Register of Systematic Reviews (PROSPERO) (registration number: CRD42020172173) and published in BMJOpen [13]. A scoping review was chosen because it is a review that identifies, summarises and appraises the existing evidence in the area of study. This type of review provides an overview of the object of study, leading to the identification of gaps, new research opportunities, limitations and strengths of published studies, and implications for clinical practice [11,12].

Eligibility criteria

For the purpose of this work, we searched for studies in English and Spanish relevant to the field of healthcare associated infections, each characterised by the use and combination of the following keywords: "healthcare-associated infection"; "educational interventions", with the greatest number of variants and opportunities, including studies of patients of all ages admitted to adult intensive care units (ICUs), regardless of length of stay. Systematic reviews, randomised clinical trials, observational studies and scoping reviews from the last decade (2013-2023) were selected.

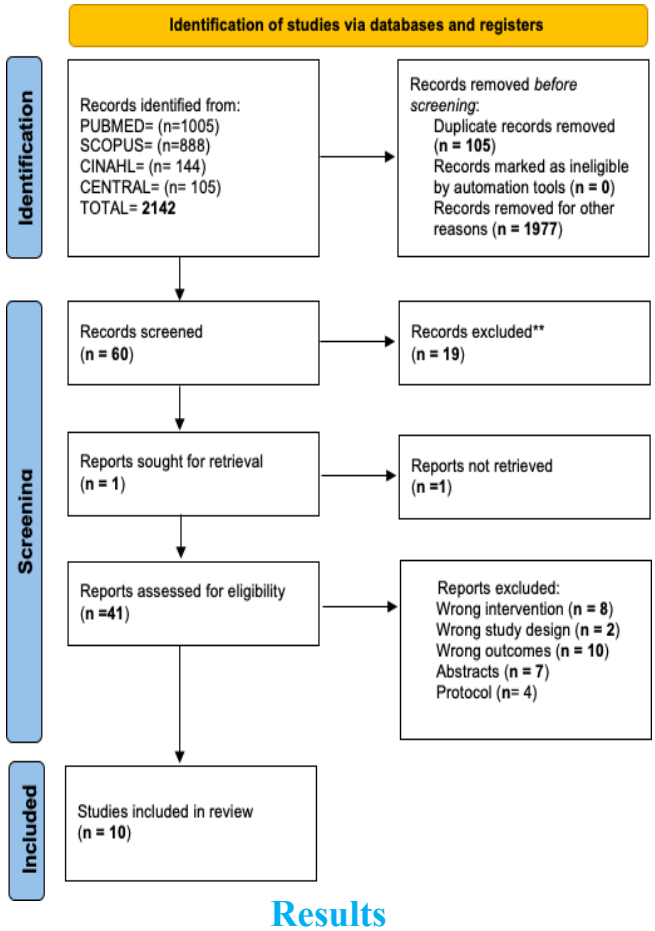
Search strategies

The search was conducted in four specialised electronic databases, PubMed, SCOPUS, CINAHL and the Cochrane Central Register of Controlled Trials (CENTRAL), in English and Spanish. Duplicate trials were removed and the remaining trials were imported into the online reference management software Mendeley. The search equation was structured using the following keyword and Boolean combinations: "healthcare-associated infections" OR "nosocomial infections" OR "hospital-acquired infections" OR "iatrogenic infections" OR "central venous catheter insertion" OR "healthcare-associated disease". Associated Disease" AND "Educational Interventions" OR "ICU Infection Prevention and Control Education" OR "ICU Infection Control Training" OR "Educational Interventions to Prevent HAIs" OR "Educational Interventions to Reduce ICU Infection Rates" OR "Healthcare Personnel Education to Prevent ICU-Acquired Infections" AND "Intensive Care Unit" OR "Intensive & Critical Care Unit".

Data extraction

A total of 2142 studies were retrieved from the four databases and duplicate studies (105) were discarded. The title and aims of each article were then checked for compatibility with the aim and population of the review. After this initial filtering, 1977 articles were discarded. The remaining 60 articles were re-checked for title, aim, year of publication, abstract and type of study; after checking that they met the eligibility criteria, 19 articles were excluded.For the 41 articles obtained, a standardised form was created that included: author (first author only), year of publication, study design, characteristics and number of participants, details of intervention and control, and results of each study. The authors carried out the analysis of the form independently, comparing the results of both, and any discrepancies found were resolved by discussion. As a result of this analysis, 29 articles were discarded, eight because they did not correspond to the type of intervention targeted by our research, two (2) because of the type of publication, 10 because they did not correspond to interventions in ICUs, and seven (7) because of the abstracts. Finally, 10 studies were included in the present review (see Figure 1).

Figure 1. PRISMA flowchart for literature search, screening and selection criteria



Results

This scoping review presents the results of the studies found on the effectiveness of educational interventions to prevent healthcare-associated infections in adult intensive care patients. The studies on which this review is based (Table 1) also evaluated interventions included in both basic and special protocols, to provide a multidisciplinary view.

Table 1. Characteristics of studies in the scoping review

Title and aim	Sample	Results		Authors
		Causes related to infections	Strategies used	
Title: Evaluation of the nurses' level of knowledge regarding hand hygiene and healthcare-associated infections: a survey. **Aim:** To evaluate nurses' knowledge of hand hygiene and healthcare associated infections (HAIs) to identify their educational needs.	236 nurses were part of a healthcare-associated infection management education programme. The study was conducted between February and June 2018.	Inadequate nurse knowledge about preventing healthcare associated infections can hinder prevention.	The training programme lasted 10 hours. A theoretical part of 8 hours (4 hours per day) and a practical part of 2 hours (1 hour per day). The strategy used was videos and practical demonstrations of hand hygiene.	Nedelcu et al. [14]
Title: Is 2- person urinary catheter insertion effective in reducing CAUTI? **Aim:** Reduce urinary catheter-associated infection rates by implementing a 2-person urinary catheter insertion protocol + checklist or nurse + staff trained in sterile technique and urinary catheter insertion.	A two-person PICU team proposed by the nursing leadership team and the CAUTI committee in two ICUs.	-Problems in maintaining aseptic technique during insertion and for the duration of catheterisation. -Inadequate use of the urinary catheter refill protocol	Application of the checklist through the 4 E's . Engage: (Commitment) . Educate . Execute . . Evaluate The prevention package has been applied: use of urinary catheters for appropriate indications, sterile technique during insertion, proper maintenance and removal when not needed. and removed when not required.	Fletcher et al. [15]
Title: Implementation of central line- associated bloodstream infection prevention bundles in a surgical intensive care unit using peer tutoring. **Aim:** Reduce CVC-associated infections in a tertiary hospital surgical intensive care unit.	Conducted in the surgical ICU of a 767-bed tertiary hospital, it compared bloodstream infection rates 9 months preoperatively, 6 months postoperatively and 9 months postoperatively.	_____	Bundle education: -Insertion: hand hygiene, maximum barrier strategies during CVC insertion, skin preparation and cleansing with chlorhexidine, avoid femoral insertion if possible. - Maintenance Feedback - regular meetings Checklists	Park et al. [16]

Table 1. Continuation

Title and aim	Sample	Results		Authors
		Causes related to infections	Strategies used	
Title: Prevention of device-related healthcare-associated infections. **Aim:** Review strategies to prevent device-associated bloodstream and urinary tract infections.	Not applicable. This is a systematic review.	Colonisation at the catheter insertion site, with migration of organisms along the external surface of the catheter, is the most common source of bloodstream infections, especially during the first week of catheterisation. The following aspects were considered: i) direct contamination of connectors/hubs resulting in internal colonisation for at least one week; ii) less frequently, catheters can be seeded haematogenously from another source of infection and iii) from contaminated intravenous fluids (iv).	Prevention strategies: 1. Basic, consisting of: i) introduction; ii) maintenance; and iii) renewal/withdrawal. 2. Special, to be considered only when bloodstream infections are not controlled by the basic strategies.	Septimus et al. 17]
Title: A compendium of strategies to prevent healthcare-associated infections in acute care hospitals: 2014 updates.**Aim:** Reduce urinary catheter- provide hospital ICUs with practical, expert guidance to help prioritise and implement their HAI prevention efforts.	Not applicable. It is a compendium	_____	Core prevention strategies identified by: i) urinary tract infections, ii) Clostridium infections, iii) surgical site infections, iv) blood stream associated infections, v) methicillin resistant *Staphylococcus aureus* infections, vi) ventilator associated pneumonia. The strategy to educate healthcare workers on infection prevention, including alternatives to catheters, handling of indwelling catheters, and insertion, handling and removal procedures is being implemented.	Yokoe et al. [18]

Table 1. Continuation

Title and aim	Sample	Results		Authors
		Causes related to infections	Strategies used	
Title: Evidence-based measures to prevent central line-associated bloodstream infections: a systematic review. **Aim:** To identify evidence-based care for the prevention of central line-associated bloodstream infections in adult patients who are hospitalised in intensive care units.	Not applicable. This is a systematic review.	_____	Primary care packages including: i) safety education/culture or organisational strategies; ii) hand hygiene, maximum barrier precautions during CVC insertion, skin preparation with chlorhexidine cleanser, avoidance of femoral CVC insertion	Perin et al. [19]
Title: Use of a daily goals checklist for morning ICU rounds: A mixed-methods study. **Aim:** To understand the perspectives and attitudes of clinicians in an intensive care unit regarding the use of a daily target checklist during rounds.	Not applicable. It is a compendium	_____	Implementation of a daily individualised checklist to identify new patient care issues.	Centofanti et al. [20]
Title: Identifying management practices for promoting infection prevention: Perspectives on strategic communication. **Aim:** Identify and describe information sharing practices used to support the prevention of healthcare associated infections (HAIs).	18 hospitals in the US between 2017 and 2019, and 188 administrative leaders and clinical clinical staff.	_____	Telling stories	McAlearney et al. [21]
Title: Prevention of Central Line-Associated Bloodstream Infections Through Educational Interventions in Adult Intensive Care Units: A Systematic Review. **Aim:** To evaluate the impact of educational interventions on CLABSI rates in adult intensive care units. The relationship between effectiveness and various characteristics of educational programmes.	27 intervention trials of central line insertion or maintenance or both. In adult intensive care units with documentation of CLABSI incidence expressed per 1000 catheter days.	_____	Simulation courses; checklists; regular follow-up and multidisciplinary interventions.	Foka et al. [22]

Table 1. Continuation

Title and aim	Sample	Results		Authors
		Causes related to infections	Strategies used	
Title: International good practices on central venous catheters' placement and daily management in adults and on educational interventions addressed to healthcare professionals or awake/outpatients. Results of a scoping review compared with the existent Italian good practices. **Aim:** Review existing international literature on the placement and management of CVCs in adults and compare with published best practice.	Not applicable. It is a scoping review	_____	They describe different interventions in the four phases: assessment; introduction; maintenance; phasing out; interventions to improve implementation and sustainability; Maintenance; Phasing out; Interventions to improve implementation and sustainability. On-the-job training programmes and courses; audit and continuous training through continuous feedback to all health workers and blended learning practices.	Mastrandrea et al. [23]

Of the studies analysed, 50% used prospective designs, and the systematic reviews examined the effectiveness of educational interventions to prevent nosocomial infections, mainly in intensive care units, as a result of CVC insertion. Thirty percent of the studies analysed the probable causes of infections, with inadequate knowledge of infection prevention and poor application of antisepsis protocols being the main causes.

Discussion

This scoping review examined in detail the studies on educational processes and their effectiveness that have been carried out on staff in healthcare institutions, particularly in adult intensive care units, to achieve appropriate use of protocols as a measure to reduce rates of infection associated with nosocomial disease. The results indicate the use of a variety of educational techniques; however, little research has determined the effectiveness of this educational process. These HCAIs represent undesirable outcomes for healthcare institutions and also have important consequences for patient outcomes, such as increased suffering and length of stay, factors that lead to higher healthcare costs, morbidity and mortality [24,25]; for example, the World Health Organization indicates that they are responsible for approximately 40000 deaths per year [26].

In ICUs, the risk of HAIs is increased compared to other services, reaching a prevalence of 20.32% as reported in the 2018 EPINE study [27]. Reasons for this increase include: *i*) the presence of a greater number of multidrug-resistant microorganisms; *ii*) the frequent use of invasive techniques; *iii*) the use of antimicrobials for long periods of time; *iv*) the use of immunosuppressive treatments; and *v*) the presence of a wide range of pathologies in critically ill patients [28]. Among the objectives proposed for this review, it was important to characterise the causes associated

with the production of HAIs. In this regard, Wisplinghoff et al. [2] in the United States evaluated the epidemiological characteristics of bloodstream infections and found that 50.5% of them occurred in the ICU. In terms of microbial isolation, this study showed that 87% were monomicrobial, with 65% caused by gram-positive microorganisms, 25% by gram-negative microorganisms and 0.9% by fungi.

In a similar study carried out by Li et al. [29], they identified coagulase-negative staphylococci (CoNS) (31% of isolates), *Staphylococcus aureus* (20%), enterococci (9%) and Candida (9%) as the most common microorganisms. The most important finding was that the proportion of methicillin-resistant S. aureus, vancomycin-resistant enterococci and *Escherichia coli* with resistance to ampicillin, piperacillin and ampicillin-sulbactam was significantly higher in the ICU than in other services. This information is crucial, as knowledge of local patterns of species distribution and infection resistance provides an adequate basis for empirical antibiotic therapy, since inappropriate antibiotic therapy increases mortality by 30-60% in ICU patients with bloodstream infections [30]; therefore, appropriate medical management of infections is part of the HCAI control programme.

With regard to the identification of interventions used to reduce HAIs in ICUs, another of the objectives proposed in this study, many international guidelines have been published with numerous proposals aimed at improving and disseminating good patient care practices. Regarding strategies, Mastrandrea et al. [23], Septimus et al. [17] and Yokoe et al. [18] agree in dividing them into basic and specific strategies; the former correspond to barrier actions applied at all stages of device management, insertion, maintenance and disposal, which should be constant in all healthcare institutions, while the latter are recommended for use when infections cannot be controlled with basic care. However, researchers such as Perin et al. do not follow the division proposed above, but present the five basic elements for HCAI prevention, including basic and special care [19].

We agree with the aforementioned researchers on the importance of the implementation of barrier protocols as an effective way to prevent HAIs; in this sense, in the present study, it was observed that the suggestions made by Pronovost et al. [8], Centofanti et al. [20], and later by Fletcher et al. [15], regarding the implementation of barrier protocols through the development of checklists based on daily goals, is an excellent strategy to prevent errors of omission and reduce errors of execution. These studies highlight the positive outcomes achieved by involving all health care staff, family, carers and the patient in the implementation of these interventions.

In 50% of the articles selected for review, researchers emphasise the importance of educational interventions for healthcare workers, mentioning education as part of a prevention package that includes safety culture and organisational strategies [19,22,23,31]. This, combined with effective education, is a practical means of monitoring standards and influencing change. These programmes should be complemented by indicators for regular monitoring, a detailed plan with concrete actions and feasible and measurable alternative solutions for outcome evaluation [32].

When organising educational programmes for healthcare workers, it is important to ensure that they are aware of their role in the production and transmission of healthcare associated infections during the performance of their activities, including patient care [33]. The type(s) of educational intervention(s) varied in the studies reviewed. Most of them used a combination of different modalities, as described by Foka et al. [22]. Among the forms of educational intervention presented in the context of infection prevention, although little documented, was the inclusion of stories and narratives, a common methodology in health education settings other than the context of the present study [34].

In North America, Europe and Asia, this technique has been used as a valuable tool to educate health professionals about patient safety [35] and has been shown to be particularly effective by focusing on narratives of realistic situations and involving the listener in the education [36]. Similarly, McAlearney et al. argue that the increased impact of information shared in this way occurs because it evokes emotion, educates and celebrates success [31]. Analysing the effectiveness of the educational interventions in the selected studies was complex because, as mentioned above, half of them described the strategies used but did not evaluate the effectiveness of these interventions. Only two studies were identified. In the study by Nedelcu et al. [14], following a training programme on hospital infection prevention, the authors assessed the level of knowledge acquired by nurses in specific areas of hand washing, disinfection and sterilisation; they found that, despite the training,

almost 68% of nurses had inadequate knowledge of these topics and 39% of them had insufficient knowledge. Although this study analysed the final outcome of the educational intervention, its effectiveness could not be evaluated because it did not include a pre-assessment of the level of knowledge of the professionals prior to the educational process.

On the other hand, Park et al. [16], through a prospective intervention in the ICU, developed an educational programme for the prevention of CVC-related infections, in contrast to the work of Nedelcu et al. [14]. These researchers evaluated three times: before the intervention, during the intervention, and nine months after the intervention; in addition, they continued to record CVC-related infection rates. The results showed a significant reduction in infections from 6.9% in the pre-intervention period to 2.4 and 1.8% in the intervention and post-intervention periods, respectively. At the three-year follow-up, infection rates were reduced to 3.0-5.4 infections per 1000 catheter days over three years. Based on the results, the authors highlight the importance of maintaining and expanding educational intervention strategies over the long term. For them, learning by teaching or peer tutoring is one of the most effective educational methods because it is participatory [16].

According to this study, it has not been possible to determine which is the most effective educational intervention to reduce healthcare associated infections, because although there are several intervention models, only one of them analyses their effectiveness. Therefore, this gap offers the possibility of developing research that not only implements several of the proposed methods in educational interventions, but also uses surveys to assess knowledge before and after the intervention, in order to compare the results obtained between them and thus determine the effectiveness of each one. One point on which the reported research agrees is the importance of regular follow-up and multidisciplinary interventions to maintain the effect and rate of reduction achieved by the intervention [37]. The reported research agrees on the importance of regular follow-up and multidisciplinary interventions to maintain the effect and rate of reduction achieved by the intervention [37].

Conclusion

This scoping review found that bloodstream infections were the most common HAI, closely followed by urinary tract infections and those associated with ventilator use. Despite the variety of educational approaches, our study found it difficult to identify the most effective strategy.

However, it was noted that 50% of the studies considered key aspects such as training, staff involvement, promotion of a safety culture and implementation of surveillance processes to achieve a reduction in nosocomial disease rates. On the other hand, the knowledge that this reduction depends on the implementation of preventive measures makes the internal audit in services and institutions important, as it requires a continuous evaluation to define the measures and the implementation of the policies necessary for their dissemination and maintenance.

These findings highlight the need for further research to determine the most effective educational interventions to prevent the development of healthcare associated infections (HAIs).

Consent for publication

The authors read and approved the final manuscript.

Competing interest

The authors declare no conflict of interest. This document only reflects their point of views and not that of the institution to which they belong.

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