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Review

Impact of educational interventions for professionals on infection control practices to reduce healthcare-associated infections and prevent infectious diseases: A systematic review

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ABSTRACT

Background: Educational interventions can decrease the rates of healthcare-associated infections (HAIs). We do not know current evidence on what kind of educational interventions are the most effective to reduce HAIs and infectious diseases. The aim of this systematic review was to examine the impact of educational interventions for health and social care professionals on infection control practices to reduce HAIs and prevent infectious diseases.

Methods: We searched for papers published between January 1, 2006 and November 16, 2021, using the CINAHL, Medic, MEDLINE, and Scopus databases. Quality appraisal was conducted using the Cochrane risk of bias tool for randomised controlled trials and ROBINS-I for quasi-experimental studies. Data were analysed using a deductive content analysis with The Guideline for Reporting Evidence-based Practice Educational interventions and Teaching checklist and The Classification Rubric for Evidence-based Practice Assessment Tools in Education as frameworks.

Findings: The data included 12 studies. Educational interventions on infection control practices have been developed as single, one-time interventions on a local basis. Two studies reported statistically significant outcomes in three of the areas evaluated, which were skills, knowledge, and self-efficacy for the first study, and benefits to the patient, behaviours, and knowledge for the second one. Benefits to the patient were evaluated in seven studies, and out of these, five showed statistically significant improvement.

Conclusions: There is currently no evidence of long-term learning paths or comparisons of different interventions to determine the most effective way to educate healthcare professionals. Statistically significant findings indicate that educational interventions on infection control practices should include both theoretical and practical learning activities.

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Summary of relevance

Problem or Issue

We do not know current evidence on what kind of educational interventions are the most effective to reduce healthcare-associated infections and infectious diseases.

What is already known

A systematic review concluded that educational interventions can decrease the rates of HAIs (Safdar and Abad, 2008). In their review, 21 studies reported a statistically significant decrease in infection rates after intervention. In 12 studies, the educational intervention resulted in compliance in hand hygiene and in three studies, better adherence to evidence-based guidelines. In the evaluation, the review focused on staff members' behavior and benefits to the patient in the form of infection rates as outcomes.

What this paper adds

This review focused on benefits to the patient, behaviors, skills, knowledge, self-efficacy, attitude, and learners' reaction to the educational experience as outcomes. Two studies reported statistically significant outcomes in three of the areas evaluated, which were skills, knowledge, and self-efficacy for the first study, and benefits to the patient, behaviors, and knowledge for the second one. Benefits to the patient were evaluated in seven studies, and out of these, five showed statistically significant improvement. The current interventions have been developed as single, one-time interventions on a local basis. There is no evidence of long-term development and testing of educational interventions for health and social professionals on infection control practices to reduce HAIs or prevent specific infectious disease.

1. Introduction

Healthcare-associated infections (herein HAIs) are infections acquired by patients during their stay in a hospital or another healthcare setting (European Centre for Disease Prevention and Control, 2022). HAIs affect more than 90,000 patients every day in European hospitals. Preventing HAIs is important for patient safety and to decrease morbidity and mortality (van der Kooi et al., 2021). In 2005, The World Health Organization (WHO) and its partners launched the Global Patient Safety Challenge with the theme "Clean Care is Safer Care" to fight the spread of HAIs, which "take a high toll in human lives and affect hundreds of millions of patients worldwide each year" (WHO, 2022). At the same time, the Advanced Draft of the WHO Guidelines on Hand Hygiene in Health Care was made available. The guidelines provide evidence-based recommendations to improve practices and reduce transmissions of pathogenic microorganisms to patients and healthcare workers (herein HCWs) (WHO, 2009).

The most common types of HAIs are different catheter-associated infections, surgical site infections, ventilator-associated pneumonia (VAP), and gastrointestinal infections like Clostridium difficile infection (European Centre for Disease Prevention and Control, 2022). The different types of catheter-associated infections are bloodstream infections (Lobo et al., 2010), peripheral venous catheter infections (Fakih et al., 2013), central-line-associated bloodstream infections (CLABSIs) (Bizzarro et al., 2010; Sabo, Sickbert-Bennett, Kellish, & Smith-Miller, 2018), and urinary tract infections (Blondal et al., 2016).

In their systematic review on educational interventions for prevention of HAIs, Safdar and Abad (2008) concluded that educational interventions can decrease the rates of HAIs. However, since the educational interventions included in their review were not well-reported, it was difficult to determine what kind of educational interventions were the most effective to prevent HAIs. The present systematic review updates knowledge on the topic by examining the impact of educational interventions for health and social care professionals on infection control practices to reduce HAIs and prevent infectious diseases. Social care was included, since in some countries, some settings in the interest of this review may not be healthcare organisations but social care settings, for example, homes for elderly people.

The research questions were:

1. What kind of educational interventions on infection control practices to reduce HAIs or to prevent infectious diseases have been used to improve infection control competence in health and social care professionals?
2. What outcomes have been achieved by using these educational interventions?

2. Methods

This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement guidelines for reporting study methods and results (Moher, Liberati, Tetzlaff, & Altman, 2009). The review protocol was registered in PROSPERO (CRD42022298334).

2.1. Search strategy

In November 2021, a systematic search of literature on educational interventions on infection control and their outcomes among health and social care professionals was performed in the CINAHL, Medic (a Finnish database of health science literature), MEDLINE, and Scopus databases, with the expert assistance of a health sciences librarian. Medic database publishes research in Finnish, Swedish, and English languages, and it is possible to find there studies

Table 1
Search terms used in databases.

Database	Search terms
CINAHL	*Headings and keywords:* (MesH "Infection Control+") OR infectio* OR control* AND educat* or train* or learn* or teach* or professional develop* AND Limiters — Published Date: 20060101-20211231; Peer Reviewed; Exclude MEDLINE records; Publication Type: Meta Analysis, Randomised Controlled Trial, Systematic Review OR quasi* OR before* after*
Medic	*Keywords:* "Infection Control"" Education" "Education") AND "Infection Control" "Education" AND "Infection Control" 2006–2021 "infektioiden torjunta" AND täydennyskoul*2006–2021
MEDLINE	*Headings and keywords:* Infection Control OR infectio* control* OR educat* or train* or learn* or teach* or professional develop* OR.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] AND limit to yr="2006 -Current" AND limit to (meta-analysis or randomised controlled trial or "systematic review") OR quasi*.mp. OR before* after*
Scopus	*Keywords:* (TITLE-ABS-KEY ("infectio* control*") AND TITLE-ABS-KEY (educat* OR train* OR learn* OR teach* OR "professional develop*") AND TITLE-ABS-KEY ("meta* analys*" OR random* OR rct OR "syst* rev*" OR quas* OR "before* after*")) AND (LIMIT-TO (PUBYEAR, 2006–2021)

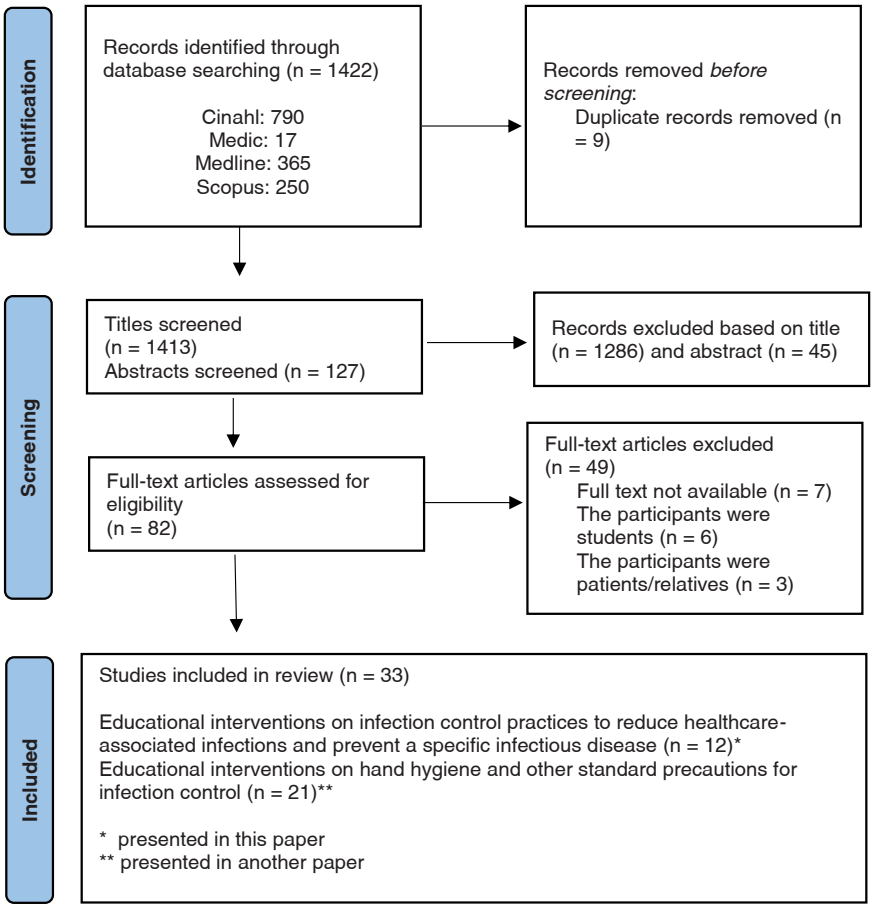

Fig. 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow chart.
From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71.

conducted in Finland, published in English. The search used appropriate subject headings and/or keywords (Table 1) with no language restrictions. The search was limited to articles published between January 1, 2006 and November 16, 2021. The starting year was determined as 2006 because in 2005, WHO made the Advanced Draft of the WHO Guidelines on Hand Hygiene in Health Care available. A non-automated search was then conducted in addition to the database searches described above, without any further results.

Fig. 1 illustrates the search and selection processes.

2.2. Study selection

The inclusion criteria were: (i) the study's participants were health and social care professionals, (ii) the study examined the impact of an educational intervention (or professional development, training, or learning) on infection control, (iii) the reported results originated from a randomised controlled trial (RCT), a quasi-experimental study design, a pretest–posttest study design, a systematic review, or a meta-analysis, and (iv) the study was published in a peer-reviewed scientific journal. The exclusion criteria were: (i) the study did not examine educational intervention, professional development, training, or learning of infection control, (ii) the participants were students only, and (iii) the participants were patients or relatives only.

The systematic selection process (Fig. 1) had three phases. After rejecting nine duplicate hits, two reviewers independently screened the eligibility of 1413 potentially relevant titles, 127 abstracts, and 82 full texts based on the above criteria. Consensus on inclusion was established by discussion.

The final data (33 articles) were divided into two categories: (i) educational interventions on infection control practices to reduce HAIs and prevent infectious diseases; (ii) educational interventions on hand hygiene (HH) and other standard precautions for infection control (Fig. 1). We analysed the data from these categories separately and report them as two separate systematic reviews. This paper reports the review of the first category.

2.3. Quality appraisal

Two reviewers independently evaluated the methodological quality of the studies included in the review using the Cochrane risk of bias tool for RCTs (Sterne et al., 2019) and ROBINS-I for quasi-experimental studies (Sterne et al., 2016). Disagreements were resolved through discussion. Of the studies, eight were evaluated to have a low risk of bias, and three showed a moderate risk of bias. One article did not report information on which to base judgement about risk of bias. The results of the quality assessment are reported in Table 2.

2.4. Data analysis

The data were analysed qualitatively using a deductive content analysis as a data synthesis method (Elo & Kyngäs 2008). In a deductive content analysis, a structured or unconstrained matrix of analysis is operationalised based on previous knowledge, such as a theory or model. All data are coded for correspondence with the aspects of the matrix; codes that fit the matrix are chosen from the data (Elo & Kyngäs 2008). A deductive approach was chosen because

Table 2
An overview of the original studies included in the review.

Authors (year), country, study design, risk of bias	Purpose of the study, development and learning content of the intervention, and the educational strategy used	Setting and participants	Data collection and analysis
(1) Abu Sharour et al. (2018), Jordan A descriptive cross-sectional, pretest–posttest quasi-experimental design Risk of bias: low	*Purpose:* To assess the effectiveness of implementing an educational module based on the Centers for Disease Control and Prevention (CDC) Guidelines (Guidelines for the Prevention of Intravascular Catheter-Related Infections) on nurses' knowledge and self-confidence. *Development:* The educational program was developed by the researcher in consultation with experts in the field. It was based on research from textbook, current literature, and the CDC guidelines. *Learning content:* The guidelines that been developed and approved by CDC; the necessary outlines including definition of central-line catheter (CVC); types of CVC (CVC, Hickman, a peripherally inserted central catheter or peripherally inserted central catheter line, and implanted port); indication for having CVC; insertion site; patient assessment before, during, and after the procedure; potential complications; nursing interventions to prevent and manage complications; caring of CVC, including dressing, aseptic fluid, flash of the lumen, fluid administration, withdrawing, clinical aspects of catheter sepsis, and indications for CVC removal; hands-on practice in caring of CVC on mannequins. *Educational strategy:* The program consisted of 25 h, of which 15 h were theoretical learning and 10 h were clinical training.	*Setting:* Oncology units. *Participants:* 100 oncology nurses (50 nurses in the experimental and 50 nurses in the control group).	*Patient data:* – *Staff data:* A knowledge-based test including 20 multiple-choice questions developed by the researcher. A self-confidence scale by Hicks (2006). The data were collected before and after the educational program. *Data analysis:* Descriptive statistics, independent t-test, and paired t-test.
(2) Acharya et al. (2019), India A quasi-experimental study Risk of bias: moderate	*Purpose:* To assess the effect of an education-based program on hand hygiene (HH) to mitigate central-line-associated bloodstream infection (CLABSI) rates in the intensive care unit (ICU) and to promote performance improvement among nursing staff. *Development:* Not reported. *Learning content:* The procedures and practices for the prevention and control of CLABSI. *Educational strategy:* A workshop with a 30-min didactic lecture and a 30-min bedside demonstration on HH and basic clinical practices.	*Setting:* Medicine ICU of a tertiary care hospital in Eastern India. *Participants:* 34 nurses	*Patient data:* CLABSI rates: 1200 catheter days and 276 patients before the intervention; 1870 catheter days and 352 patients after the intervention. *Staff data:* Nurses' compliance with HH observed by the infection control nurse. Knowledge test with a questionnaire. The data were collected immediately after and at 3 and 6 months after the intervention. *Data analysis:* Mann–Whitney U-test, Chi-square test, and Fisher's exact test.
(3) Akande (2020), Nigeria A quasi-experimental study Risk of bias: moderate	*Purpose:* To utilise a multi-method educational intervention to improve tuberculosis-infection-control-related (TBIC-related) knowledge and practices of nurses in two secondary health facilities in Ibadan, Nigeria. The specific objectives of the study were to evaluate the effectiveness of the training at 6 months and to assess if there was sustained effect at 12 months. *Development:* The educational intervention was based on materials on tuberculosis by WHO and U.S. Centers for Disease Control and Prevention. *Learning content:* WHO and U.S. Centers for Disease Control and Prevention (CDC) materials on TBIC, implementing TBIC in outpatient settings, HH training recommended by WHO. *Educational strategy:* A multi-method educational intervention consisting of didactic lectures in the form of PowerPoint presentations, a 14-min video presentation, discussion, and practical demonstration sessions. Handouts and lecture notes were provided as reminders. Signages, posters, and stickers in TBIC workplace practices were displayed at the facility after the training.	*Setting:* 2 secondary health facilities in two separate local government areas in Ibadan. *Participants:* 200 nurses (100 nurses in the intervention group (IG) and 100 nurses in the waitlist control group, trained after data collection at 6 months).	*Patient data:* – *Staff data:* A self-administered questionnaire measuring socio-demographic characteristics, TBIC-related knowledge, and TBIC-related practices. The scales were adapted from a previously used (Kanjee et al., 2012) instrument. The data were collected before the intervention and at 6 months and 12 months after the intervention. *Data analysis:* Means, frequencies, independent t-test, and Chi-square test.
(4) Aloush (2018), Jordan A randomised controlled trial Risk of bias: moderate	*Purpose:* To evaluate the effectiveness of the CVC-RI (central venous catheter-related infection) prevention guidelines educational course presented to ICU nurses in Jordanian hospitals. *Development:* The educational course was based on the CVC-RI prevention guidelines by the CDC. *Learning content:* CVC types, indications, insertion, complications, nurses' role	*Setting:* 10 Jordanian urban area ICUs out of which most were medical surgical units. Four were governmental, two educational, and four were private hospitals. *Participants:* 131 registered nurses (65 nurses in the experimental and 66 nurses in the control group).	*Patient data:* – *Staff data:* A questionnaire was developed based on the CVC-RI prevention guidelines from the CDC, comprising biographical details and a multiple-choice exam. The data were collected before the intervention and after the intervention. Data collection took 2 months.

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Table 2 (*continued*)

Authors (year), country, study design, risk of bias	Purpose of the study, development and learning content of the intervention, and the educational strategy used	Setting and participants	Data collection and analysis
	in the prevention of complications, and updated guidelines for prevention of CVC-RI. *Educational strategy:* Three lecture sessions of 3 h each consisted of video recordings, classroom presentation, and class discussion. All sessions were prepared and delivered by the principal investigator.		*Data analysis:* Descriptive statistics, means, independent-sample t-test, and paired-sample t-test.
(5) Alrubaiee et al. (2021), Yemen A single-blinded randomised hospital-based trial Risk of bias: low	*Purpose:* To evaluate the implementation of an educational module on nosocomial infection (NI) control measures among Yemeni nurses. *Development:* Not reported. *Learning content:* Overview of NIs, point-of-care risk assessment, HH, personal protective equipment, safe injection practices, reprocessing of patient care equipment, routine hospital cleaning, safe linen handling, safe hospital waste handling and disposal, source control, and module reflection. *Educational strategy:* A multimodal learning strategy consisted of a face-to-face training course (three educational units, 20 h in total, spanning over 6 weeks). The learning materials were a hard copy of the educational module (60 pages) and a CD containing short videos related to NI control measures.	*Setting:* Eight public hospitals *Participants:* 540 nurses assigned to two IGs and a waitlist group (WG). IG 1 (n = 180) received the face-to-face training course, IG 2 (n = 180) received the hard copy of the educational module 'without training', and WG (n = 180) did not receive anything.	*Patient data:* – *Staff data:* A self-administered questionnaire developed in this study. It comprised socio-demographic details, knowledge of NI, and practice of NI control measures. The data were collected before the intervention and at 6 weeks and 3 months after the end of the intervention. *Data analysis:* Chi-square test, Kruskal–Wallis test, generalised estimating equation, Wald Chi-Square test, simple main effects test, and relatively straightforward post hoc analysis (pairwise).
(6) Baldwin et al. (2010), Northern Ireland, UK A cluster randomised controlled trial (cRCT) Risk of bias: low	*Purpose:* To test, in a cRCT, the effect of an infection control education and training intervention programme delivered to nursing home staff on MRSA prevalence in these facilities. *Development:* Not reported. *Learning content:* In-depth information on infection control, HH, decontamination of equipment, and the environment. *Educational strategy:* A 2-h training session delivered via PowerPoint, DVD presentations, and practical demonstrations. The sessions were repeated at 3 and 6 months after each infection control audit and feedback. Additional 5-h training for infection control links workers selected from each intervention home.	*Setting:* 32 general nursing homes with ≥20 residents (12 homes in the experimental and 12 homes in the control group). *Participants:* 464 residents aged ≥65 years (excluding the terminally ill or those attending on a day-care basis only) (232 residents in the experimental and 232 residents in the control group). 338 nursing home staff members (all occupations).	*Patient data:* Age, gender, presence of wounds or indwelling devices, history of hospitalisation and antibiotic use in the previous 3 months, and history of chronic illnesses. The primary outcome was MRSA prevalence in residents. *Staff data:* Occupation, age, and gender. *Nursing home data:* The number of beds (occupancy and capacity), staffing levels, ownership type (private or other), and infection control audits for nursing homes using an audit tool adapted from one previously developed for community practice use (Department of Health 2005). The data were collected at baseline and at 3, 6, and 12 months after the education. *Data analysis:* An intention-to-treat basis. Random effects meta-analysis models, paired-sample t-tests.
(7) Branco et al. (2020), Brazil A quasi-experimental, retrospective study Risk of bias: low	*Purpose:* To evaluate nursing adherence to the ventilator-associated pneumonia (VAP) prevention bundle and the VAP incidence rate, before and after continuing education. *Development:* – *Learning content:* VAP diagnosis, risk factors and prevention strategies, presentation of the bundle, situation of the team's adherence to preventive measures, and the importance of patient safety in the ICU. *Educational strategy:* On-site, 20-min sessions through a multimedia resource.	*Setting:* General adult ICU of a large hospital in Porto Alegre/RS. *Participants:* 48 nursing professionals.	*Patient data:* Profile of 302 patients submitted to the ventilator, admitted to the adult ICU, and the incidence density rate of VAP before and after the education. *Staff data:* Adherence and registration of nurses to the VAP prevention bundle before and after the education by analysing patient records. *Data analysis:* Descriptive statistics with relative and absolute frequencies, mean (or median), standard deviation, minimum and maximum, Chi-square test, Student's t-test, Mann–Whitney tests, and logistic regression analysis.
(8) Chun et al., (2015), Korea A quasi-experimental study Risk of bias: low	*Purpose:* To increase the frequency and level of thoroughness of HH as practiced by nurses who were given individual feedback after a HH education session, and to assess the influence of the methicillin-resistant *Staphylococcus aureus* (MRSA)-acquired incidence rate and MRSA colonisation pressure. *Development:* The education was developed based on guidelines released by the CDC and the World Health Organization and study results regarding the effect of HH. *Learning content:* Proper methods of HH and the importance of HH. *Educational strategy:* A 30-min group education	*Setting:* A medical ICU in a tertiary care university teaching hospital with 850 beds. *Participants:* 24 nurses.	*Patient data:* MRSA screening by nasal swab culture within 24 h of admission and then once a week thereafter. *Staff data:* Observations on HH frequency and methods were documented based on a localised Korean tool adopted from the Association for Professionals in Infection Control guidelines. Data were collected before the education program and 1 week and 6 weeks afterwards. *Data analysis:* Chi-square test, one-way ANOVA, Dunnett's multiple comparisons, and Fisher's exact tests.

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Table 2 (*continued*)

Authors (year), country, study design, risk of bias	Purpose of the study, development and learning content of the intervention, and the educational strategy used	Setting and participants	Data collection and analysis
	session at the end of the working day with a PowerPoint presentation. It was repeated for 5 days to ensure that all received it. Confidential individual feedback on the appropriateness and frequency of HH was provided for each participant 10 min after the session.		
(9) Monistrol et al. (2012), Spain A prospective before–after interventional study Risk of bias: low	*Purpose:* To evaluate the impact of a multimodal intervention in medical wards on HH compliance, alcohol-based hand rub (AHR) consumption, and incidence of hospital-acquired infection (HAI) and hospital-acquired methicillin-resistant *Staphylococcus aureus* (HA-MRSA). *Development:* The educational program was developed by infection control staff using the social learning theory of Bandura (1982). *Learning content:* HH opportunities based on WHO guidelines, AHR when indicated, and HH techniques. *Educational strategy:* A total of 37 targeted 20-min face-to-face educational seminars as group sessions for all shifts, assessment of HH technique of the participants with an ultraviolet radiation lamp, leaflets, pictures showing the correct steps for hand washing as reminders, and six different motivational posters, which were replaced monthly.	*Setting:* Three internal medical wards with 113 beds in a 500-bed tertiary care hospital. *Participants:*132 healthcare workers (HCWs).	*Patient data:* Incidence density and risk factors for HAI and HA-MRSA: diagnosing and classifying of HAIs according to the standard definitions of the CDC, screening of MRSA colonisation, and recording of MRSA isolates from clinical samples obtained 48 h after admission; intrinsic risk factors were recorded according to Charlson (Charlson et al., 1987) and Barthel (Mahoney et al., 1965) scores, and extrinsic risk factors were the presence of indwelling devices and length of hospital stay. *Staff data:* HH compliance was measured using direct observation of HCWs during their daily work routine, following WHO guidelines on HH in healthcare recommendations, and a form validated by WHO. A total of 1531 HH opportunities were observed. Data were collected before the intervention, during the intervention, and 10 weeks and 1 year after the intervention. *Data analysis:* Chi-square test, Fisher's exact test, Student's t-test, Mann–and Whitney U-test.
(10) Negm et al. (2021), Egypt A quasi-experimental study Risk of bias: No information on which to base judgement about risk of bias	*Purpose:* To evaluate the impact of the implementation of a comprehensive care bundle educational program on reducing device-associated infections (DAIs) and mortality rates in an emergency ICU and to improve HCWs' knowledge and compliance with care bundles. *Development:* Educational needs assessment was collected before the intervention from the records, by interviewing the ICU staff, from clinical rounds discussion, with the help of expert opinion. *Learning content:* Device care bundles and infection control measures: HH, disinfection and sterilisation, and personal protective equipment. *Educational strategy:* 30-min lectures to small groups, daily on-the-job training during clinical rounds, and weekly 90-min seminars. PowerPoint presentations, coloured posters with motivational messages, HH posters, workplace reminders about device care bundle components, leaflets, flowcharts, and didactic videos.	*Setting:* A 15-bed emergency ICU. *Participants:* HCWs on duty (n = 70).	*Patient data:* The data of 240 patients (120 in each place) were collected using the checklist on background information and incidence rates of DAI and mortality rates for DAI before and after the intervention. *Staff data:* Compliance with care bundles was measured using checklists, and knowledge was assessed using a semi-structured questionnaire adapted from a similar study (Sodhi et al., 2013). Data were collected before and 1 year after the intervention. *Data analysis:* Frequencies, relative percentages, relative risk and relative risk reduction, Chi-square test, Fisher's exact test, and McNemar test.
(11) Pun et al. (2016), Hong Kong A controlled trial Risk of bias: low	*Purpose:* To evaluate the effectiveness of a computer-based training system proposed for catheter-access hemodialysis (HD) training with a controlled trial. *Development:* The proposed catheter-access HD management training system was designed based on standard guidelines adopted by the hospital. *Learning content:* Proper HD techniques, the sequence of the procedures, and the use of the materials and equipment required for managing the catheter site in an aseptic manner. The major catheter-access HD procedures covered preparing the patient, dressing the exit site of the catheter, preparing the HD trolley, disinfecting the percutaneous catheter, testing the blood flow in the percutaneous catheter, connecting to the blood circuit, and the aftercare procedures. *Educational strategy:* A web-based training lasting 15 min, consisting of online training exercises, a video, an interactive game, and including a training mode and a testing mode.	*Setting:* A sub-acute care private hospital in Hong Kong. *Participants:* 40 nurses (in the control group, 20 nurses received conventional training only; in the experimental group, 20 nurses received conventional training and computer-based training).	*Patient data:* – *Staff data:* The HD knowledge test developed in this study based on standard guidelines of the hospital, the HD skills competence checklist developed and used by the hospital, the Technology Acceptance Questionnaire designed based on the Technology Acceptance Model, and the IBM Computer System Usability Questionnaire designed by IBM. Data were collected before and right after the intervention. *Data analysis:* Frequencies, percentages, means, standard deviations, and Chi-square test.

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Table 2 (*continued*)

Authors (year), country, study design, risk of bias	Purpose of the study, development and learning content of the intervention, and the educational strategy used	Setting and participants	Data collection and analysis
(12) Szilagyi et al. (2021), USA A 2-group, longitudinal parallel cluster RTC Risk of bias: low	*Purpose:* To evaluate the effect of an online communication training intervention for primary care paediatric clinicians to improve their communication skills regarding human papillomavirus (HPV) vaccination. *Development:* The online modules were based on prior studies of practice improvement, which had used group conference calls and webinars. *Learning content:* HPV disease burden, how to give an effective HPV recommendation using a "same way same day approach" to introduce HPV vaccination the same way that clinicians typically introduce other vaccines, how to answer common questions by parents or adolescents, strategies to engage office staff in communication about the HPV vaccine, and how to address parental hesitancy. *Educational strategy:* An online communication training with three online modules, viewable using a computer, tablet, or smartphone. Weekly quick tips sent as reminders.	*Setting:* 48 US paediatric primary care clinics. *Participants:* The IG comprised 24 practices with 188 clinicians and the control group comprised 24 practices with 177 clinicians.	*Patient data:* Missed opportunities for HPV vaccination overall and at well-childcare visits or visits for acute or chronic illness, and HPV vaccination rates were evaluated using EHR data. To determine vaccine eligibility, dates of initial and subsequent HPV vaccinations were assessed using 2018 Advisory Committee on Immunization Practices criteria. Data on adolescents' visits to the practice were extracted from EHRs, including adolescent characteristics, visit date, Evaluation and Management Current Procedural Terminology codes to identify well-childcare or acute or chronic visits, and initial or subsequent HPV vaccination. *Staff data:* Participants' use of communication skills, confidence in communication about the HPV vaccine, and time spent discussing HPV vaccination with parents were assessed with an instrument developed using the RE-AIM [Reach, Effectiveness, Adoption, Implementation, and Maintenance] framework. Data were collected before and 6 months after the intervention. *Data analysis:* Logistic regression models.

two appropriate frameworks for creating structured matrices were available.

The educational interventions were described using the Guideline for Reporting Evidence-based Practice Educational interventions and Teaching (GREET) checklist as a framework (Phillips et al., 2016). The GREET checklist is a specific, reliable, and valid reporting guideline designed to provide a framework for consistent and transparent reporting of educational interventions for evidence-based practice (herein EBP) (Phillips et al., 2016). It comprises 17 items (Table 3) that are recommended for reporting EBP educational interventions. The more detailed descriptions of the items can be found in the article by Phillips et al. (2016). These items constituted the structure of the matrix of analysis. Although GREET has been designed for such EBP interventions whose learning content are the steps of EBP (one of the items of the checklist), it was chosen for use here because the other 16 items were directly suitable for the purpose of this review, and the item concerning learning content was adapted here to be "learning content on infection control".

Coding was initially done by two reviewers separately determining whether each item was addressed in the study being reviewed; if the item was addressed, a cross was placed in the corresponding cell of Table 3. The reviewers mostly agreed within the items immediately, however within differing views, they discussed the grounds for the decision, until consensus was reached. The coded results are presented in Table 3 and discussed in the text.

2.5. Outcomes

The main outcome of this systematic review was benefits to patients. Benefits to the patient relate to the impact of EBP educational interventions on patients' care (Tilson et al., 2011). The CREATE includes seven categories whose assessment is recommended when implementing educational interventions on EBP. Benefits to the patients are one of the seven categories of the CREATE taxonomy. The others are behaviour, skills, knowledge, self-efficacy, attitude, and reaction to the educational experience. These six categories have been examined as additional outcomes of this systematic review. Although CREATE has been designed for such EBP interventions whose learning content is the steps of EBP, it was used here because the assessment areas were suitable for the purpose of this review. The reviewers mostly agreed within the categories immediately, however within differing views, they discussed the grounds for the decision, until consensus was reached. The authors of one article were contacted to obtain more information about the outcome evaluation of their work.

3. Results

3.1. Overview of the studies included in the review

The data analysed in this review included 12 original studies. An overview of these studies is presented in Table 2. Five of these studies were RCTs, five were quasi-experimental studies, one had a descriptive cross-sectional design, and one a pretest–posttest design.

In four studies, the educational intervention was targeted at reducing central-line catheter-associated infections (Abu Sharour et al., 2018; Acharya, Bedanta Mishra, Ipsita, & Azim, 2019; Aloush, 2018; Pun, Chiang, & Choi, 2016). Three of the educational interventions were targeted at reducing methicillin-resistant *Staphylococcus aureus* (MRSA) rates (Baldwin et al., 2010) or MRSA and colonisation (Chun, Kim, & Park, 2015; Monistrol et al., 2012). One educational intervention was targeted at preventing VAP (Branco, Lourencone, Monteiro, Fonseca, & Blatt, 2020) and one at preventing device-associated infections (DAIs) in general (Negm et al., 2021). One educational intervention was targeted at improving prevention of tuberculosis (Akande, 2020) and one at prevention of nosocomial infections via increasing nurses' knowledge of these infectious diseases (Alrubaiee et al., 2021). One educational intervention was targeted at increasing rates of human papillomavirus (HPV) vaccination (Szilagyi et al., 2021).

Table 3
Synthesis of the GREET checklist (Phillips et al., 2016[a]) items used in reporting in original studies.

The GREET checklist item/study	1.Abu Sharour et al. (2018)	2.Acharya et al. (2019)	3.Akande (2020)	4.Aloush (2018)	5.Alrubaiee et al. (2021)	6.Baldwin et al. (2010)	7.Branco et al. (2020)	8. Chun et al., (2015)	9. Monistrol et al. (2012)	10.Negm et al. (2021)	11.Pun et al. (2016)	12.Szilagyi et al. (2021)
1. INTERVENTION: Provide a brief description of the educational intervention for all groups involved [e.g., control and comparator(s)].	x		x		x	x	x	x	x	x	x	x
2. THEORY: Describe the educational theory(ies), concept, or approach used in the intervention.									x			
3. LEARNING OBJECTIVES: Describe the learning objectives for all groups involved in the educational intervention.												
4. LEARNING CONTENT ON INFECTION CONTROL PRACTICES: The original item by Phillips et al. (2016) is "EBP CONTENT" meaning a list of the foundation steps of EBP included in the educational intervention, which are ask, acquire, appraise, apply, and assess. This item was adapted to be suitable for the topic of this review.	x	x	x	x	x	x	x	x	x	x	x	x
5. MATERIALS: Describe the specific educational materials used in the educational intervention. Include materials provided to the learners and those used in the training of educational intervention providers.			x		x	x			x	x	x	x
6. EDUCATIONAL STRATEGIES: Describe the teaching/learning strategies (e.g., tutorials, lectures, and online modules) used in the educational intervention.	x	x	x	x	x	x	x	x	x	x	x	x
7. INCENTIVES: Describe any incentives or reimbursements provided to the learners.												
8. INSTRUCTORS: For each instructor involved in the educational intervention, describe their professional discipline, teaching experience/expertise. Include any specific training related to the educational intervention provided for the instructor(s).					x	x						
9. DELIVERY: Describe the modes of delivery (e.g., face-to-face, internet, or independent study package) of the educational intervention. Include whether the intervention was provided individually or in a group and the ratio of learners to instructors.	x	x	x	x	x	x	x	x	x	x	x	x
10. ENVIRONMENT: Describe the relevant physical learning spaces (e.g., conference, university lecture theatre, hospital ward, and community) where the teaching/learning occurred.			x			x		x	x	x	x	x
11. SCHEDULE: Describe the scheduling of the educational intervention, including the number of sessions, and their frequency, timing, and duration.			x		x	x		x	x	x		x
12. Describe the amount of time learners spent in *face-to-face contact* with instructors and any designated time spent in self-directed learning activities.	x				x		x	x	x	x	x	x

(*continued on next page*)

Table 3 (*continued*)

The GREET checklist item/study	1.Abu Sharour et al. (2018)	2.Acharya et al. (2019)	3.Akande (2020)	4.Aloush (2018)	5.Alrubaiee et al. (2021)	6.Baldwin et al. (2010)	7.Branco et al. (2020)	8. Chun et al., (2015)	9. Monistrol et al. (2012)	10.Negm et al. (2021)	11.Pun et al. (2016)	12.Szilagyi et al. (2021)
13. Did the educational intervention require specific *adaptation* for the learners? If yes, please describe the adaptations made for the learner(s) or group(s).			x									
14. Was the educational intervention *modified* during the course of the study? If yes, describe the changes (what, why, when, and how).									x			
15. ATTENDANCE: Describe the learner attendance, including how this was assessed and by whom. Describe any strategies that were used to facilitate attendance.	x	x	x	x	x	x	x	x	x	x	x	x
16. Describe any processes used to determine whether the materials (item 5) and the educational strategies (item 6) used in the educational intervention were *delivered as originally planned*.												
17. Describe the extent to which the number of sessions, and their frequency, timing, and duration for the educational intervention were *delivered as scheduled* (item 11).												

GREET: Guideline for Reporting Evidence-based Practice Educational interventions and Teaching; EBP: evidence-based practice.

[a] The checklist is published with permission of the authors.

Most of the study settings were limited to adult care and one (Szilagyi et al., 2021) educational intervention was focused for paediatric clinicians. Most of the studies were conducted in hospital settings: in intensive care (Acharya et al., 2019; Aloush, 2018; Branco et al., 2020; Chun et al., 2015), in an emergency intensive care unit (ICU) (Negm et al., 2021), in a medical ward (Monistrol et al., 2012), in a hemodialysis ward (Pun et al., 2016), in an oncology ward (Abu Sharour et al., 2018), or in a hospital setting in general (Akande, 2020; Alrubaiee et al., 2021). One study was conducted in a primary care setting (Szilagyi et al., 2021). One study focused on the education of staff in nursing homes for elderly people (Baldwin et al., 2010).

The educational interventions were either focused for HCWs or nursing staff in general (Abu Sharour et al., 2018; Acharya et al., 2019; Akande, 2020; Alrubaiee et al., 2021; Branco et al., 2020; Chun et al., 2015; Monistrol et al., 2012; Negm et al., 2021; Pun et al., 2016), or specifically for registered nurses (Aloush, 2018) or physicians (Szilagyi et al., 2021). The study that focused on nursing homes (Baldwin et al., 2010) defined the participants as 'staff' in general.

Two of the studies were conducted in Jordan (Abu Sharour et al., 2018; Aloush, 2018), the others were conducted in India (Acharya et al., 2019), Nigeria (Akande, 2020), Yemen (Alrubaiee et al., 2021), the United Kingdom (Baldwin et al., 2010), Brazil (Branco et al., 2020), Korea (Chun et al., 2015), Spain (Monistrol et al., 2012), Egypt (Negm et al., 2021), Hong Kong (Pun et al., 2016), and the United States (Szilagyi et al., 2021).

3.2. Description of the educational interventions

The educational interventions were described using the GREET checklist (Phillips et al., 2016) as a framework (Table 3), and the results are presented according to it. None of the 12 studies alone described all 17 elements of the educational intervention included in the GREET checklist.

Ten of the studies provided a *brief description of the educational intervention*, and two (Acharya et al., 2019; Aloush, 2018) did not. One study described the *educational theory* used in the intervention (Monistrol et al., 2012), which was Bandura's (1982) social learning theory. None of the studies described the *learning objectives* for the learners. However, one study (Alrubaiee et al., 2021) reported the aim of the educational module, which was to enhance nurses' knowledge about nosocomial infection (NI) control measures and enable the nurses to apply them in real clinical situations. All studies reported the *learning content on infection control practices* included in the educational intervention. The learning contents are presented in detail in Table 2.

Materials provided for the learners during the educational interventions were described in seven studies. These materials were lecture notes (Akande, 2020; Alrubaiee et al., 2021), CD videos (Alrubaiee et al., 2021; Negm et al., 2021) PowerPoint handouts (Baldwin et al., 2010; Negm et al., 2021), reminders and leaflets/handouts (Akande, 2020; Monistrol et al., 2012; Negm et al., 2021; Szilagyi et al., 2021), signage (Akande, 2020), posters (Akande, 2020,; Monistrol et al., 2012; Negm et al., 2021), stickers (Akande, 2020), or hard copies of educational materials (Alrubaiee et al., 2021).

Educational strategies were described in all studies. Eleven studies used lectures as one educational strategy (Abu Sharour et al., 2018; Acharya et al., 2019; Akande, 2020; Aloush, 2018; Alrubaiee et al., 2021; Baldwin et al., 2010; Branco et al., 2020; Chun et al., 2015; Monistrol et al., 2012; Negm et al., 2021; Szilagyi et al., 2021), often combined with other strategies: workshop discussions (Acharya et al., 2019; Aloush, 2018; Alrubaiee et al., 2021; Monistrol et al., 2012), practical training sessions (Baldwin et al., 2010), role play (Alrubaiee et al., 2021), or independent reading of reminders and handouts sent to the learners after the lectures (Akande, 2020; Negm et al., 2021). One study (Pun et al., 2016) used only computer-based online training exercises as a strategy.

None of the studies provided any *incentives* for the learners.

Instructors of the educational interventions were mentioned in two of the studies (Alrubaiee et al., 2021; Baldwin et al., 2010). In one study, an educational module on nosocomial infections was delivered by three specialist nurses who held a master's degree in nursing (Alrubaiee et al., 2021). In the other study, an infection control nurse implemented an infection control education and training intervention on MRSA for nursing home staff (Baldwin et al., 2010).

Modes of delivery of educational intervention were described in all studies. Face-to-face contact learning was included in eight educational interventions (Abu Sharour et al., 2018; Acharya et al., 2019; Akande, 2020; Aloush, 2018; Alrubaiee et al., 2021; Chun et al., 2015; Monistrol et al., 2012; Negm et al., 2021) and distance learning in four (Baldwin et al., 2010; Branco et al., 2020; Pun et al., 2016; Szilagyi et al., 2021) interventions.

The *environment* was reported in seven studies (Akande, 2020; Baldwin et al., 2010; Chun et al., 2015; Monistrol et al., 2012; Negm et al., 2021; Pun et al., 2016; Szilagyi et al., 2021). In all of these studies, the educational intervention was implemented as hospital base in-service education.

The educational intervention *schedule* was reported in seven studies (Akande, 2020; Alrubaiee et al., 2021; Baldwin et al., 2010; Chun et al., 2015; Monistrol et al., 2012; Negm et al., 2021; Szilagyi et al., 2021). The number and intervals of the sessions, and the delivery time period, were presented in six of these studies (Akande, 2020; Alrubaiee et al., 2021; Baldwin et al., 2010; Chun et al., 2015; Monistrol et al., 2012; Negm et al., 2021). The number of the sessions varied from 3 (Akande, 2020) to 37 (Monistrol et al., 2012). The sessions were repeated every fifth day (Chun et al., 2015), once a week (Negm et al., 2021), 3–6 months' time (Baldwin et al., 2010), or the sessions were available every day during a specific period of time (Szilagyi et al., 2021).

The amount of *time* the learners spent in *face-to-face contact* was mentioned in 10 studies (Abu Sharour et al., 2018; Acharya et al., 2019; Akande, 2020; Aloush, 2018; Alrubaiee et al., 2021; Baldwin et al., 2010; Branco et al., 2020; Chun et al., 2015; Monistrol et al., 2012; Negm et al., 2021). In theoretical learning sessions, the duration of face-to-face time was 20 min (Branco et al., 2020; Monistrol et al., 2012), 30 min (Acharya et al., 2019; Chun et al., 2015; Negm et al., 2021), 2 h (Baldwin et al., 2010), 3 h (Aloush, 2018), 15 h (Abu Sharour et al., 2018), or 20 h (Alrubaiee et al., 2021). For those studies with clinical learning, the face-to-face time was either 30 min (Acharya et al., 2019) or 10 h (Abu Sharour et al., 2018). In one study, face-to-face contact was reported as participation in clinical rounds during a week of on-the-job training (Negm et al., 2021).

The amount of *time* spent on *self-directed learning activities* differed between studies: 15 min in a computer-based training (Pun et al., 2016), 20–30 min in online sessions (Szilagyi et al., 2021), and 3 h in reading a self-directed PowerPoint presentation (Akande, 2020).

Adaptations for learners were made in one study. The training time was shortened to train as many nurses as possible (Akande, 2020).

Educational intervention was *modified* in one study. After the initial HH seminar, an ultraviolet radiation lamp was added to the protocol to assess the HH technique (Monistrol et al., 2012).

The learner *attendance* was reported in all studies. The attendants were described as follows: nurses/registered nurses (Abu Sharour et al., 2018; Acharya et al., 2019; Akande, 2020; Aloush, 2018; Alrubaiee et al., 2021; Branco et al., 2020; Chun et al., 2015; Pun et al., 2016), HCWs (Monistrol et al., 2012; Negm et al., 2021), nursing home staff (Baldwin et al., 2010), and clinicians (Szilagyi et al., 2021). The number of learners varied from 24 to 540 attendants.

Table 4
Evaluation areas of the educational interventions in the original studies and the significance level[a] of the results.

The CREATE framework (Tilson et al., 2011)[b] assessment category/study		1.Abu Sharour et al. (2018)	2.Acharya et al. (2019)	3.Akande (2020)	4.Aloush (2018)	5.Alrubaiee et al. (2021)	6.Baldwin et al. (2010)	7.Branco et al. (2020)	8. Chun et al., (2015)	9. Monistrol et al. (2012)	10.Negm et al. (2021)	11.Pun et al. (2016)	12.Szilagyi et al. (2021)
7	Benefits to the patient[c]	Patient-oriented outcomes	SS				SS	SS	SS	SS	i		CI
6	Behaviours	Activity monitoring	SS			SS		SS	SS		SS		i
5	Skills	Performance assessment	SS	SS	SS							SS	
4	Knowledge	Cognitive testing	SS	SS	SS	SS					SS	SS	
3	Self-efficacy	Self-report/ opinion	SS										FC
2	Attitude												
1	Reaction to the educational experience											pp	

HPV: human papillomavirus.
[a] Statistically significant improvement $p < 0.05$ (SS); improvement percentage shown with no information on statistical significance (i); a positive perception of the training (pp); improvements shown with 95% confidence intervals (CI); most participants reported feeling confident (FC) answering questions about the HPV vaccine or talking with hesitant parents.
[b] The framework is published with the permission of the authors.
[c] The main outcome of this systematic review.

None of the studies reported any processes used to determine whether the materials and/or educational strategies were *delivered as originally planned* or whether the number of sessions or their frequency, timing, and/or duration were *delivered as scheduled*.

3.3. Outcomes of the educational interventions

The outcomes of the educational interventions on infection control were described by using the CREATE taxonomy (Tilson et al., 2011) as a framework (Table 4). The main outcome — *benefits to the patient* — was evaluated in seven studies (Acharya et al., 2019; Baldwin et al., 2010; Branco et al., 2020; Chun et al., 2015; Monistrol et al., 2012; Negm et al., 2021; Szilagyi et al., 2021) and five of these showed statistically significant outcomes. MRSA prevalence and colonisation among patients (Baldwin et al., 2010; Chun et al., 2015; Monistrol et al., 2012), the rates of DAIs (Branco et al., 2020), and CLABSI rates (Acharya et al., 2019) decreased after the educational intervention. Additionally, one study (Negm et al., 2021) showed decreasing DAIs in an emergency ICU but with no indication of whether it was statistically significant. One study (Szilagyi et al., 2021) reported increasing HPV vaccination rates, including 95% confidence intervals.

Behaviour (i.e., what learners actually do in practice) improved in five studies. There was a statistically significant improvement in nurses' NI control measures (Alrubaiee et al., 2021). Implementation of care bundles resulted in a statistically significant change in behaviour in two studies. A VAP prevention bundle education program increased nurses' adherence to the bundle (Branco et al., 2020), and a comprehensive care bundle educational program improved nurses' compliance with a device care bundle (Negm et al., 2021). After HH education and individual feedback on HH behaviour, the nurses' behaviour regarding the care of patients with MRSA infection showed a statistically significant improvement and the rates of MRSA infections decreased (Chun et al., 2015). One study reported an increase in recommendation of the HPV vaccination for adolescents by clinicians (Szilagyi et al., 2021) after the educational program. However, only the improvement percentage was shown, and statistical significance was not reported.

There was a statistically significant improvement in how learners apply their knowledge ideally in a practical setting (i.e., *skills)* in three studies. After the educational program, nurses' skills improved in the prevention of catheter-associated infections (Abu Sharour et al., 2018; Pun et al., 2016) and in tuberculosis-infection control (Akande, 2020).

Knowledge on infection control practices was evaluated in seven studies, and in six cases (Abu Sharour et al., 2018; Akande, 2020; Aloush, 2018; Alrubaiee et al., 2021; Negm et al., 2021; Pun et al., 2016), the participants self-evaluated it. One study (Acharya et al., 2019) included a knowledge test. There were statistically significant improvements in nurses' knowledge after the educational program in five studies whose educational intervention focused on reducing central-line-associated infections (Abu Sharour et al., 2018; Acharya et al., 2019; Aloush, 2018; Pun et al., 2016) or DAIs (Negm et al., 2021). Nurses' knowledge on tuberculosis (Akande, 2020) and non-socomial infections (Alrubaiee et al., 2021) improved after the educational interventions.

Two of the studies evaluated learners' *self-efficacy*. After the educational program, there was a statistically significant improvement in oncology nurses' confidence in managing central-line catheters (Abu Sharour et al., 2018) and clinicians reported feeling confident answering questions about the HPV vaccine or talking with hesitant parents (Szilagyi et al., 2021).

None of the studies evaluated participants' *attitudes*.

Learners' *reaction to the educational experience* was measured in one study (Pun et al., 2016), evaluating the effectiveness of a computer-based training. With the Technology Acceptance

Questionnaire, participants gave a positive rating to the usefulness and ease of use of the computer-based training, their intention to use it, and attitude toward using it.

To conclude the results, two educational interventions (Abu Sharour et al., 2018; Acharya et al., 2019) showed statistically significant improvements in five different areas evaluated (benefits to the patient, behaviour, skills, knowledge, and self-efficacy). Common elements for these two interventions were that both included theoretical and practical learning activities. The elements of the educational interventions were poorly reported though, and this is why it is difficult to determine which elements were most effective. The study design of these two interventions was quasi-experimental and the risk of bias was low (Abu Sharour et al., 2018) or moderate (Acharya et al., 2019). The main outcome of our review — benefits to the patient — was evaluated in one of these two studies (Acharya et al., 2019). There were six other studies reporting benefits to the patient (Baldwin et al., 2010; Branco et al., 2020; Chun et al., 2015; Monistrol et al., 2012; Negm et al., 2021; Szilagyi et al., 2021), and out of these, four showed statistically significant results (Baldwin et al., 2010; Branco et al., 2020; Chun et al., 2015; Monistrol et al., 2012). Finding the possible common elements between the five interventions showing statistically significant results regarding benefits to the patient (Acharya et al., 2019; Baldwin et al., 2010; Branco et al., 2020; Chun et al., 2015; Monistrol et al., 2012) is difficult, mainly because of the scant information about the interventions.

4. Discussion

4.1. Consideration of the findings

The aim of this systematic review was to examine the impact of educational interventions for health and social care professionals on infection control practices to reduce HAIs and prevent infectious diseases. We found 12 studies, out of which only five (Aloush, 2018; Alrubaiee et al., 2021; Baldwin et al., 2010; Pun et al., 2016; Szilagyi et al., 2021) were RCTs. The rest were either pretest–posttest design (Abu Sharour et al., 2018; Monistrol et al., 2012) or quasi-experimental (Acharya et al., 2019; Akande, 2020; Branco et al., 2020; Chun et al., 2015; Negm et al., 2021) studies. All interventions reported were self-developed. They all were implemented only once and on a local basis. In the future, it would be very important to standardise the interventions to make them replicable and comparable in different contexts. Moreover, future interventions should be described in detail. Detailed description of an intervention makes it replicable (Phillips et al., 2016).

Description of the educational interventions in original studies was varied and vaguely reported, and therefore it is difficult to draw conclusions about which elements of the interventions were effective in improving infection control competence in health and social care professionals. None of the studies reported the learning objectives of the education. Only one study reported the goal of the intervention, however, this is not exactly the same thing as a learning objective. Learning objectives include information about matters that the learners are expected to learn (Harden, 2007a), and they may also give guidance on the level of mastery required by learners (Harden, 2007b). Information about these two things guides the selection of learning content, learning strategies, and assessment methods, and since the learning objectives were not reported in the original studies of this review, it is not possible to fully evaluate the relevance of the learning content, learning strategies, or assessment methods selected for the interventions. It remains unclear if the designers of the educational interventions in the original studies were actually using formulated learning objectives, but did not report them in the articles, or if the learning objectives had even been formulated at all. However, since the role of the learning objectives is so important in learning and teaching processes, they should be formulated and reported very clearly.

Learning strategies were reported in all the studies and there was variation between them. Two interventions (Abu Sharour et al., 2018; Acharya et al., 2019) showed statistically significant improvements in three areas evaluated (skills, knowledge, and self-efficacy). Common elements for these two were that both included theoretical and practical learning activities. Tentatively, in the future, we would recommend combining both theoretical and practical learning activities in educational interventions on infection control. Combining theory and practice would give the learners an opportunity to be active learners who integrate thinking and acting and reflect on the act, which enhances learning (Wrenn & Wrenn, 2009).

The teachers of the educational interventions were mainly nurses. Multi-professional collaboration in the development or implementation of the educational intervention was not mentioned in any of the studies we included. In two articles (Abu Sharour et al., 2018; Negm et al., 2021), experts were mentioned, however, there was no further information about their expertise. In 11 of the included studies, the educational intervention was conducted among nurses or among nurses and other healthcare professionals as participants. In one article, participants were reported as clinicians, with no further information about their professions. Since infection control competence requirements involve all healthcare professions, we recommend focusing educational interventions on infection control for multi-professional groups when possible. This would also demand planning and implementing the education on a multi-professional basis.

Four of the studies had short follow-up times (Llewellyn-Bennett, Bowman, & Bulbulia, 2016), with just one measurement point immediately after the intervention (Abu Sharour et al., 2018; Branco et al., 2020; Chun et al., 2015; Pun et al., 2016). The longer follow-ups (Llewellyn-Bennett et al., 2016) were from 6 weeks to 6 months (Acharya et al., 2019; Aloush, 2018; Alrubaiee et al., 2021; Szilagyi et al., 2021) or one year (Acharya et al., 2019, 6; Monistrol et al., 2012; Negm et al., 2021). Studies with longer follow-ups are recommended in order to show whether learning results are permanent or not.

The evaluation of the outcomes related to knowledge were mostly evaluated as a self-assessment, which is not always reliable because it is a subjective assessment method (Inayah et al., 2017). Using a knowledge test is a more objective form of knowledge assessment (Warwick, 2023), but it was only used in one study (Pun et al., 2016); in this study, statistical analysis showed no significant differences in participants' knowledge before and after the education.

Attitudes were not evaluated in any of the studies, even though attitude is a significant part of learning and behaviour change. Moreover, attitudes play a significant role in infection control practices (Stein, Makarawo, & Ahmad, 2003). These reasons are why attitudes should also be evaluated in educational interventions on infection control.

Learners' reaction to the educational experience was evaluated in only one study (Pun et al., 2016). However, the result was not clearly reported. Although learners' feedback is not a direct measure of learning, it gives important information for course designers and teachers about the learners' perspective on how successful the different elements of an educational intervention are (Tilson et al., 2011), and this is why collecting and reporting on it are recommended.

Two studies reported statistically significant outcomes in three of the areas evaluated, which were skills, knowledge, and self-efficacy for the first study, and benefits to the patient, behaviours, and knowledge for the second one. Benefits to the patient were evaluated in seven studies, and out of these, five showed statistically significant improvement. Since some educational interventions had

reached good results, the use of effective educational interventions for health and social care professionals on infection control practices can be recommended to reduce HAIs and prevent infectious diseases.

Two educational interventions showed statistically significant improvements in five different areas evaluated. Common elements for these two interventions were that both included theoretical and practical learning activities and thus, the use of both approaches can be recommended.

There was no evidence of long-term development and testing of these interventions, which would be needed to find the most effective ways to educate healthcare professionals. The interventions included in this review were robust in terms of their content, since many interventions were based on guidelines or other evidence. However, the interventions were often poorly reported, which provides a challenge for future studies on the topic.

4.2. Strengths and limitations

To ensure that the search process was both systematic and extensive, it was carried out with an information specialist and by using database directories. The list of search terms was designed to be wide-ranging. These were reported accurately to ensure repeatability.

Two authors worked independently to select the papers, but the selection process and ambiguous cases were discussed together, which added to the reliability of the data. The papers were initially chosen based on their titles, and, therefore, it is possible that some relevant studies may have been left out. On the other hand, the reference sections of the articles chosen for the review did not indicate any need to repeat the search process. It is unlikely that there were language or publication biases, since when screening the titles, the authors did not find any publications that may have been eligible for inclusion that were published in any language other than English.

Information on the original studies was documented in a matrix and careful use of this information in the analysis increased the reliability of the review. We used the GREET checklist (Phillips et al., 2016), which is a reliable and valid reporting guideline designed to provide a framework for the consistent and transparent reporting of educational interventions regarding EBP; we adopted this for the analysis of the educational interventions included in this review, with one small adaptation, with the permission of the developers of the checklist. The checklist was well-suited for the purposes of this review and the use of it enhances the validity of the review. In the analysis, we used the CREATE taxonomy (Tilson et al., 2011), which has been developed by a specialist group and covers seven areas of evaluation of EBP educational interventions. It was adapted here, with the permission of the developers, for the analysis of the outcomes of the original studies, which strengthens the validity of this review.

The quality of the original studies was generally good. In eight of the studies, the risk of bias was evaluated to be low and in three studies it was moderate. One of the articles did not report information on which to base a judgement about the risk of bias. There is a potential limitation regarding the amount of evidence included in this review due to deficiencies in the reporting of the original studies.

5. Conclusions

To describe the educational interventions on infection control practices to reduce HAIs or prevent specific infectious disease, we analysed 12 studies. The main finding was that educational interventions on infection control practices have been developed as single, one-time interventions on a local basis. The outcomes achieved by using these educational interventions were examined on seven evaluation areas. Two studies reported statistically significant outcomes in three of the areas evaluated, which were skills, knowledge, and self-efficacy for the first study, and benefits to the patient, behaviours, and knowledge for the second one. Benefits to the patient were evaluated in seven studies, and out of these, five showed statistically significant improvement.

Lessons for practice

- Effective educational interventions for health and social care professionals on infection control practices are recommended to reduce HAIs and prevent infectious diseases.
- The learning objectives of the educational interventions on infection control practices should be formulated and reported very clearly.
- Educational interventions on infection control practices should include both theoretical and practical learning activities.

Authorship contribution statement

Koota, Kaartinen, and Melender: the conception and design of the review. Koota and Melender: acquisition of data. Koota and Melender: analysis and interpretation of the data. Koota and Melender: drafting the article. Koota, Kaartinen, and Melender: revising the article critically for important intellectual content. Koota, Kaartinen, and Melender: final approval of the version to be submitted.

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Conflict of interest

None to report.

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