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State of the Science Review

Risk factors for health care–associated infection in hospitalized adults: Systematic review and meta-analysis

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Background: Health care–associated infections (HAIs) are a public health problem that increase health care costs. This article aimed to systematically review the literature and meta-analyze studies investigating risk factors (RFs) independently associated with HAIs in hospitalized adults.
Methods: Electronic databases (MEDLINE, Embase, and LILACS) were searched to identify studies from 2009-2016. Pooled risk ratios (RRs) or odds ratios (ORs) or mean differences (MDs) and 95% confidence intervals (CIs) were calculated and compared across the groups. This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement.
Results: Of 867 studies, 65 met the criteria for review, and the data of 18 were summarized in the meta-analysis. The major RFs independently associated with HAIs were diabetes mellitus (RR, 1.76; 95% CI, 1.27-2.44), immunosuppression (RR, 1.24; 95% CI, 1.04-1.47), body temperature (MD, 0.62; 95% CI, 0.41-0.83), surgery time in minutes (MD, 34.53; 95% CI, 22.17-46.89), reoperation (RR, 7.94; 95% CI, 5.49-11.48), cephalosporin exposure (RR, 1.77; 95% CI, 1.30-2.42), days of exposure to central venous catheter (MD, 5.20; 95% CI, 4.91-5.48), intensive care unit (ICU) admission (RR, 3.76; 95% CI, 1.79-7.92), ICU stay in days (MD, 21.30; 95% CI, 19.81-22.79), and mechanical ventilation (OR, 12.95; 95% CI, 6.28-26.73).
Conclusions: Identifying RFs that contribute to develop HAIs may support the implementation of strategies for their prevention, therefore maximizing patient safety.

Health care–associated infections (HAIs) have become a global public health problem that involves serious health risks and increases health care costs each year. Human suffering is an immediate implication of these infections, given that they reduce the quality of life of patients and their relatives.[1,2]

A U.S. prevalence survey estimated that there were 722,000 HAIs in hospitals and approximately 75,000 HAIs-related deaths in 2011, with >50% occurring outside intensive care units (ICUs).[1] Each year in Europe, HAIs cause 16 million additional hospitalization days, cause 37,000 attributable deaths, and contribute to an additional 110,000 deaths. Annual financial losses are estimated at around €7 billion, including direct costs. Information about epidemiology of HAIs in low- and middle-income countries is very scarce, with limited published data available.[3]

Any infection that a patient contracts after hospitalization is considered an HAI, regardless of procedure or department, including outpatient and homecare treatment, and infections acquired from health professionals.[4] Several risk factors (RFs) predispose patients to develop HAIs. Intrinsic RFs encompass the physiologic characteristics or conditions of the individual at the time of admission, and extrinsic RFs involve all measures related to the treatment instituted to the patient.[5]

In the hospital context, there are a number of RFs associated with HAIs; however, there must be an adequate number of pathogens present to cause an infection. Infectious agents transmitted during health care are primarily derived from human sources, but inanimate environmental sources have also been implicated in transmission.[6] Among the RFs for HAIs are health and disease status,

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treatment, invasiveness, and environmental methods to which the patient are exposed. Therefore, the determinants of hospital infection risk are the characteristics and exposures of patients that predispose them to infections. The epidemiology of HAIs shows that some RFs are nonmodifiable.[7]

According to the European Centre for Disease Prevention and Control, approximately 20%-30% of HAIs are considered preventable through intensive hygiene and control programs.[8] Most prevention measures are costly; however, in many cases, they are well below the cost of treating patients with HAIs. Prevention efforts must begin with a culture change in patient care because it is known that controlling and preventing hospital infections represent a challenge for patient safety and quality of care. However, for these changes to occur, it is necessary to understand which factors increase a patient's risk of acquiring an infection.

It is essential, therefore, to determine the RFs that contribute to HAIs. Most related studies have focused only on a single RF, but given the complexity and extent of the subject, there is a need for broad global investigation into which factors are frequently presented by patients and the relationships these factors have with HAIs, because the implementation of procedures, interventions, and measures to eliminate or minimize HAIs depends on their adequate recognition in different hospital environments. Therefore, this study aimed to systematically review the literature and meta-analyze studies investigating RFs independently associated with HAIs in hospitalized adults.

METHODS

This systematic review (SR) and meta-analysis followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement.[9] The protocol was registered on the PROSPERO International Prospective Register of Systematic Reviews (registration no. CRD42016042487).

Data sources and search strategy

The following 3 databases made available by the Federal University of Rio Grande do Sul were used: PubMed/MEDLINE, Embase, and LILACS. The 3 databases cited were chosen for their representativeness in the health area and for having a wide range of scientific production in North America, Europe, Latin America, and the Caribbean.

The electronic search was performed on databases including publications from January 2009- December 2016 using Descriptors in Health Sciences in Brazilian Virtual Health Library for searches in LILACS, Medical Subject Headings terms for searches in PubMed/MEDLINE, and Embase Subject Headings terms for searches in Embase according to the strategies subsequently described.

The following search strategies were used: PubMed/MEDLINE: risk assessment[majr] OR inpatients[majr] OR patient safety[majr] OR risk factors[majr] OR infection control[majr] OR cross infection[majr] AND risk factors AND infection; Embase: "risk assessment"/exp/mj OR "inpatients"/exp/mj OR "patient safety"/exp/mj OR "infection"/exp/mj OR "infection control"/exp/mj OR "cross infection"/exp AND "risk factors"; and LILACS: (tw:(risk assessment)) OR (tw:(inpatients)) OR (tw:(patient safety)) OR (tw:(infection control)) OR (tw:(cross infection)) AND (tw:(risk factors)) AND (tw:(infection)).

Study inclusion and exclusion criteria

We included analytical observational studies, randomized clinical trials (RCTs), and SRs published in Portuguese, English, or Spanish that addressed infection RFs in hospitalized adults or estimated RFs independently associated with HAIs. Editorials letters, conference summaries, qualitative and descriptive studies, and articles addressing mortality-related RFs were excluded.

Data extraction

Article identification and selection were conducted independently by 2 reviewers (A.L.R.-A. and B.E.). Disagreements were resolved by discussion with and analysis by a third reviewer (W.C.-M.). Articles identified in duplicate in several databases were computed only once. Zotero, version 4.0.28.7 (Center for History and New Media, George Mason University, Fairfax, VA) was used to store references and remove duplicates.

Quality assessment

The methodologic quality of the included studies was evaluated using 3 instruments: the Newcastle-Ottawa Scale (NOS),[10] Assessment of Multiple Systematic Reviews (AMSTAR),[11] and the Cochrane Collaboration's tool for assessing risk of bias in randomized trials. The Cochrane Collaboration risk of bias tool for RCTs is available in RevMan 5.1 (Cochrane Community, Copenhagen, Denmark). Joanna Briggs Institute (JBI) recommendations were used to evaluate the evidence level of the studies.

Data analysis

RevMan 5.1 software was used for analysis. A meta-analysis was performed to compute the pooled effect estimate with a random-effects model for either binary or continuous outcomes when there were at least 2 studies included. For dichotomous outcomes, the Mantel-Haenszel method was applied to calculate the risk ratio (RR) or odds ratio (OR) and corresponding 95% confidence interval (CI). For continuous outcomes, the inverse variance weighting was applied to calculate the mean difference (MD) and corresponding 95% CI. Statistical heterogeneity was evaluated using the I^2 statistic. The data abstracted from the individual studies were pooled to determine the effect estimate. Publication bias was assessed using a funnel plot.

RESULTS

Identification and selection of studies

A total of 867 articles were identified, of which 65 studies were included in the SR, and the data of 18 were summarized in the meta-analysis. The flowchart for the selection and exclusion of studies is presented in Figure 1.

Characteristics of the included studies

An overview of the studies is provided in Supplementary Table S1, showing a summary of the selected studies, including authors, year of publication, country, RFs for infection, design, and methodologic quality according to the NOS and AMSTAR tools, and the JBI evidence levels.

The distribution showed a recent downward trend: 38 (58.5%) of the studies were published between 2009 and 2012, whereas 27 (41.5%) were published between 2013 and 2016. Most of the studies had an observational design: there were 40 (61.5%) prospective-retrospective cohort studies, 14 (21.6%) were case-control studies, 5 (7.7%) were cross-sectional studies, 5 (7.7%) were SRs, and 1 (1.5%) was an RCT.

The studies were conducted in a total of 24 different countries: 10 (15.4%) in the United States; 7 (10.8%) in Spain; 5 (7.7%) each in Brazil, France, Turkey, and the United Kingdom; 3 (4.6%) each in