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Relationship between prevalence of device-associated infections and alcohol-based hand-rub consumption: a multi-level approach

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SUMMARY

Using a multi-level logistic regression model, we determined whether there was any relationship between alcohol-based hand-rub consumption and prevalence of device-associated infections (DAIs) in French healthcare facilities (HCFs). Two national databases were used: the 2006 French prevalence survey of nosocomial infections, and the 2006 French infection control indicator database which includes alcohol-based hand-rub consumption as an indicator (ICSHA: indicateur de consommation de solution hydro-alcoolique). Only patients with at least one medical device (urinary catheter, vascular catheter or tracheal tube) who were present in an HCF for at least two days were included in the analysis. A multi-level statistical analysis was performed to assess the joint effect of patient-level and hospital-level variables. In all, 814 HCFs, each with a minimum of 15 study patients, were included, giving a total of 53 459 patients. The overall prevalence of DAI was 6.7% (95% confidence interval: 6.4–6.9). The median value of ICSHA was 37.2%. There was no association between DAI prevalence and ICSHA, but all patient-level variables were associated with DAI prevalence. Patient-level variables explain 25% of the hospital-level variation in DAI prevalence, although 60% of this variation remains unexplained when both patient and hospital variables are included in the model. To further assess any association between DAI prevalence and hand hygiene, additional studies on hand hygiene practices specifically associated with invasive medical device manipulation are required.

Introduction

Healthcare-associated infections (HAIs) lead to increases in morbidity and mortality as well as in hospitalisation costs and length of stay. Their management is therefore a major ongoing challenge for any institution. Factors favouring HAI development include the patient's medical condition (age and underlying disease), treatments such as antibiotics or immunosuppressives, and the presence of invasive devices.[1] Device-associated infections (DAIs) account for a substantial proportion of HAIs. The latest French National Prevalence Survey (NPS) reports that 26.6% of patients have at least one invasive device.[1] The most commonly used devices are vascular catheters (24%), urinary catheters (9.4%), and tracheal tubes (1.8%). In intensive care units (ICUs), the prevalence of tracheal tube usage is 41.5%. Between 9% and 27% of these patients suffer from ventilator-associated pneumonia (VAP), which represents 2.1–10.7 episodes of VAP per 1000 days of ventilation.[2] Similarly, vascular catheters may cause catheter-associated bloodstream infection (CABSI) which accounts for an estimated 87 500–350 000 infections in the USA each year.[2] In 2009, an annual French ICU survey showed that 23.8% of bacteraemias occur in patients with vascular catheters. According to the 2006 NPS, the urinary tract represents the main site of infection, accounting for more than 30% of nosocomial infections.[1] Urinary catheters are also responsible for 3.1–7.7 catheter-associated urinary tract infections (CAUTIs) per 1000 urinary catheter-days.[2]

The presence of an invasive medical device creates a risk for hand transmission of infection through recurrent manipulation; and the World Health Organization recommends good hand-hygiene practice before manipulation of such devices. Use of

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alcohol-based hand rub (ABHR) has been promoted as a quick, effective, and easy means of hand disinfection; hence alcohol-based hand hygiene is recognised as a leading measure for reducing healthcare-associated infection and preventing DAI. Although the relationship between hand disinfection and multidrug-resistant bacteria such as meticillin-resistant *Staphylococcus aureus* (MRSA) is well described,[3–8] its relationship with DAI has been less well studied.[9,10]

In this study, we used a multi-level analysis to assess whether there was any association between ABHR consumption and the prevalence of DAI in French healthcare facilities (HCFs). We also evaluated whether this relationship varied according to the type of DAI (CABSI, CAUTI or VAP).

Methods

Definitions

Healthcare-associated infection was defined as an infection not found to be present or incubating at the time of admission. DAI was defined according to the recommendations of the French Ministry of Health (MoH) and the US Centers for Disease Control and Prevention.[11] CAUTI was defined as signs of urinary infection associated with the presence of a urinary catheter on the same day or within the previous seven days, with positive urinary culture ($\geq 10^5$ micro-organisms/mL) for one or two different micro-organisms. CABSI was defined as bacteraemia occurring within 48 h of catheter removal and a positive culture of the catheter or insertion site with the same micro-organism, or central line and peripheral blood culture with the same micro-organism. VAP was defined as pneumonia occurring in a patient whose respiration was assisted by a ventilator.

ICSHA (indicateur de consommation de solution hydro-alcoolique) is the French index of consumption of ABHR solution. This indicator is defined for each healthcare facility by the MoH as the ratio of the volume of ABHR ordered to the personalised objective of volume of ABHR to be used by that HCF over the year. The personalised objective was calculated by considering the number of annual patient-days per specialty, and a volume of 3 mL for each opportunity of hand disinfection. With respect to each specialty, the MoH considered there to be 48 minimum opportunities for hand rubbing per patient per day in ICUs, nine in surgical units, eight in obstetric units, seven in medical units, five in chronic care units, four in long term care units, and two in psychiatric units.

Data sources

Data were obtained from two databases that were merged using a code linked to the hospital administration ID number. The first database, the 2006 NPS, includes information on patient and HCF characteristics (2337 HCFs accounting for 358 353 patients). Public and private HCFs were invited to include information on all inpatients present on a given date between 29 May and 30 June 2006 (each establishment could choose the day of the survey). With the help of a physician or nurse on each ward, trained investigators used standardised questionnaires to collect data on all patients and any present nosocomial infection. Clinical and microbiological data were collected from medical records, microbiology laboratories, temperature charts, and interviews with ward staff. Data were entered by each hospital using a standardised database programme and were aggregated at regional and national level.

The second database was the 2006 French Infection Control Indicators database which contains ICSHA values for each HCF (Figure 1).

Study population

All patients or hospitals with missing data were excluded. We chose to evaluate the relationship between ABHR and DAI, and therefore only patients with a medical device (urinary catheter, vascular catheter, or tracheal tube) who were present in the HCF for at least two days were retained for analysis. In this population, the prevalence of DAI was 6.7% (95% confidence interval: 6.4–6.9). To be able to observe at least one event in each HCF, we restricted our analysis to institutions with at least 15 included patients.[12] The final study population consisted of 53 459 inpatients from 814 HCFs (Figure 1).

Specific study population

To analyse the impact of ICSHA on different DAIs, specific subpopulations were defined among the total study population, to include only patients with urinary catheter for CAUTI, vascular catheter for CABSI, or tracheal tube for VAP. VAP was studied only in ICUs. In these subpopulations, we calculated the prevalence of CAUTI, CABSI, and VAP as well as the minimum number of patients required per HCF to be able to observe at least one event.

The prevalence of CAUTI for the subpopulation of patients with urinary catheters was 6.5% and only HCFs with at least 16 patients were included. The prevalence of CABSI for patients with vascular catheters was 0.7% and HCFs needed to have at least 143 patients to be included. Finally, the prevalence of VAP among patients with tracheal tubes was 22.4% and only HCFs with intensive care units of least five patients were included for this subpopulation.

The final sizes of the subpopulations were 17 700 patients with urinary catheters from 422 hospitals, 13 869 patients with vascular catheters from 55 hospitals, and 1537 patients with tracheal tubes from 112 hospitals.

Outcome and explanatory variables

Outcome was assessed as a binary variable that indicated whether a given patient had a DAI recorded on the day of the survey. In addition, the following characteristics were considered as potential confounders at the patient level: sex, age, length of stay, patient's ward (medicine, paediatrics, surgery, intensive care, gynaecology, emergency, and other), intrinsic risk factors (immunodeficiency and McCabe score),[13] and extrinsic risk factors (presence of at least one invasive device and/or surgery within the previous 30 days). As in other studies, age was categorised as <65 or ≥ 65 years.[3,9] Length of stay was defined as either 2–5 days or as >5 days.

At the HCF level, the main explanatory variable of interest was the ICSHA indicator; other data included were status of HCF (public, private for-profit or private not-for-profit), and type of HCF (university hospital, general hospital, chronic and long term care, and others including clinics and cancer centre).

Statistical analysis

Chi-square tests were used to compare individual variables (sex, age, length of stay, patient's ward, immunodeficiency, McCabe score and surgery within the previous 30 days) according to the infection status of the patient. $P < 0.05$ was considered statistically significant. Analyses were performed with Epi Info 6.04 (1996, Centers for Disease Control and Prevention, Atlanta, GA, USA).

We used a two-level hierarchical logistic regression model that accounts for the hierarchical structure of data, with patient at the first level nested within hospital for the second level. First, we