Preventing Healthcare-Associated Infections by Avoiding Unnecessary Hospitalization: Cohort Study

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Abstract

Background

Healthcare-associated infections (HAI) are major public health problem. The primary care is a key component of health systems, integrating the care across the care levels. Preventing unnecessary hospitalizations is one of objectives of primary care, thus avoiding exposing the patient to iatrogenic risks, such as HAI. The so-called Primary Care Sensitive Conditions (PCSC) have been used as an indicator that measures the effectiveness of primary care. This study aims at to identify whether there is an association between PCSC and HAI.

Methods

Prospective cohort with a nested case-control study. Sampling included 605 adult patients with more than 48 hours of hospitalization in public tertiary-care hospital in São Paulo, Brazil. We used structured questionnaire to characterize sociodemographic and clinical profile of participants. The information about hospitalization due to PCSC was collected from the patients' medical record. The infection control team identified HAI cases in the routine surveillance using standard criteria. Multilevel regression model and the propensity score for case matching were used for data analysis.

Results

In our cohort, 55 (9.1%) patients were admitted due to PCSC. Overall, 32 (5.3%) of the cohort patients developed HAI. The Human Development Index of cities of patients' origin was high, varying from 0.72 to 0.81, and the Gini index varied from 0.41 to 0.67. The average family income was around 2.5 Brazilian minimum wages (equivalent to USD 691.24 at the time of the study). We observed no relevant differences among patients with HAI or regarding individual or social indicators. The multilevel regression showed an odds ratio of 2.877 (95% CI: 0.960–8.262; p = 0.05) for potential association of HAI and PCSC, but not significant. In the analysis of the case-control study based on propensity balance, the group with PCSC had an odds ratio of 1.795 (95% CI 0.390–8.270) for the presence of HAI, but without statistical significance (p = 0.707).

Conclusion

This study did not demonstrated statistical association between HAI acquisition and PCSC. However, it is still unclear how much HAI rates are influenced by vulnerability conditions of patients that could be prevented by efficient primary care.

Background

Healthcare-associated infections (HAI) are major problems of public health and patient safety [1, 2]. HAI have an important impact on morbidity and mortality, hospitalization time, increased cost with treatment for the health system, and may contribute to the increase of antimicrobial resistance [2].

There is a knowledge gap whether the determinant for high HAI rates is exclusively linked to deficits in the quality of hospital care or whether other social factors are also involved in this process. Thus, identifying the social factors associated with HAI acquisition process has become a major challenge when evaluating public policies addressed to HAI prevention [3].

Among the social factors involved, the access to efficient primary care is a potential relevant issue. Primary care is a key component of healthcare system, operating as an integrating element across the healthcare levels [4]. Hospitalizations due to the so-called Primary Care Sensitive Conditions (PCSC) have been used as an indicator to measure the effectiveness of primary care [5]. Preventing unnecessary hospitalization avoids the exposition of patients to iatrogenic risks such as HAI [6] We raised the hypothesis that patients admitted due to PCSC may be more susceptible to acquire HAI, however, we did not find any study exploring this potential association.

The objective of our study was to identify whether there is an association between PCSC and HAI.

Methods

Study design

This is a prospective cohort study with a nested case-control.

Settings and participants

The sampling included 605 adult inpatients (> 18 years old) with more than 48 hours of hospitalization in different clinical and surgical units in a public tertiary-care hospital (with 910 beds, including 107 intensive care beds), in the State of São Paulo, Brazil. Sampling was calculated based on a 10% HAI rate and 8 to 20% of PCSC according to Brazilian literature, with a study power of 85% and alpha of 5%.

Data collection procedures

This study was conducted from May to December 2018. The exclusion criteria were patients hospitalized in intensive care units, coming from cities outside the state of São Paulo, transferred from other hospitals, and with hospitalization in the previous month. Cases of deaths in less than 48 hours of hospitalization or surgical procedure were also excluded. Patients were followed up until hospital discharge or death, or with 30 days of hospitalization; we considered only the first episode of HAI.

The HAI cases were identified by the infection control team as per their routine, by using active surveillance and the criteria standardized by the Centers of Diseases Control adapted by the National Agency of Sanitary Surveillance in Brazil (available in: http://portal.anvisa.gov.br)

The participants were interviewed by the researcher using a quantitative structured questionnaire, which contained sociodemographic variables (e.g. sex, age, income, and schooling years) and information about their access to the healthcare system. Socioeconomic variables of the Municipal Human Development Index (MHDI) and the Gini Index were obtained from Brazilian data sources (http://tabnet.datasus.gov.br/cgi/ibge/censo/cnv/ginibr.def) according to the city of origin of patients. We collected variables such as PCSC, clinical conditions, and use of medical devices from the medical records. The Brazilian national list was used to define patients with PCSC based on the International Classification of Disease - Tenth Revision (ICD-10) diagnosis codes as the main reason for hospitalization [7]

Statistical Analysis

Statistical analysis of multilevel regression model was performed in the cohort to evaluate the HAI outcome with PCSC, and with selected variables. The multilevel considered two layers: individual risk factors and social-economics related to the city of the patient's origin. We also carried out a nested case-control study, using the propensity score for case-matching to select controls to be included in this analysis. The IBM Statistical Package for the Social Sciences (SPSS) software version 19 was used. In all analyses, the significance level was considered as < 0.05.

Results

Among the 605 eligible participants included, we found 32 (5.3%) episodes of HAI and 55 (9.09%) having PSCS as the main reason for hospitalizations. Among the group that was admitted for the diagnosis of PSCS, 5 (0.8%) acquired HAI.

Most of the patients were female 345 (57%), and black or brown 320 (52.9%). The median age of the patients was 52.8 years, ranging from 18 to 99 years. The average schooling was 8.5 years and the family income 2.5 Brazilian minimum wages (equivalent to USD 691.24 at the time of the study). Patients were originated from cities where the MHDI ranged from 0.72 to 0.81 and the Gini from 0.41 to 0.67 (Table 1).

Table 1
Distribution of demographic, socioeconomic and clinical profile of patients with or without HAI (n = 605). São Paulo, Brazil, 2018.

Variable	With HAI (n = 32)	Without HAI (n = 573)	*P*-value*
Sex	20 (62.5)	240 (41.8)	**0.027**
Male	12 (37.5)	333 (58.1)	
Female			
Age, years (mean)	57	52.6	-
Self-reported ethnicity	18 (56.3)	254 (44.3)	0.095
White	12 (37.5)	308 (53.7)	
Black or Brown	0 (0.0)	4 (0.7)	
Indigenous	2 (6.3)	7 (1.2)	
Asian			
Schooling years (mean)	8.8	8.5	0.736
Family income (average)**	650.37	713.44	0.136
HDI	0.74–0.86	0.71–0.88	-
Gini index	0.45–0.67	0.41–0.67	-
Charlson index	6 (18.7)	150 (26.2)	0.136
0	10 (31.2)	183 (31.9)	
1–2	8 (25)	153 (26.7)	
3–4	8 (25)	87 (15.2)	
> 5			
Specialty	17 (53.1)	303 (52.8)	1.000
Clinical	15 (46.8)	270 (47.1)	
Surgical			
ICU	12 (37.5)	104 (18.1)	**0.011**
Yes	20 (62.5)	469 (81.8)	
No			

* Exact Fisher Test p < 0.05

** Reference: December 2018: USD 1 = R$3.856 (at the time of the study)

Variable	With HAI (n = 32)	Without HAI (n = 573)	*P*-value*
Use of invasive medical device	20 (62.5)	151 (26.3)	**< 0.001**
Yes	12 (37.5)	422 (73.6)	
No			
* Exact Fisher Test p < 0.05			
** Reference: December 2018: USD 1 = R$3.856 (at the time of the study)			

Aside from the main reasons for hospitalization, the most frequent comorbidities of the studied population were hypertension 271 (44.7%), diabetes 157 (26%), and cancer 91 (15%). In the group of patients with HAI, the proportion of diabetes was higher (40.6%, n = 13).

HAI cases were distributed as: seven (21.8%) cases of surgical site infection (SSI), seven of central line-associated bloodstream infection (CLABSI), six of (18.8%) urinary tract infection, four (12.5%) of osteomyelitis, three (9.4%) of pneumonia not related to mechanical ventilation, two (6.3%) of vascular access infection, and one (3.1%) case of upper respiratory tract infection, gastroenteritis, and soft tissue infection, respectively.

The most frequent PCSC were stroke in 17 (30.9%) patients, followed by diabetes mellitus 10 (18.2%), and kidney and urinary tract infection 5 (9.1%). There were only two cases of death in the group without HAI.

In the group of patients with admission due to PCSC who acquired HAI, the most frequent PCSC were diabetes, and the HAI sites were osteomyelitis (n = 2), CLABSI (n = 2), and urinary tract infection (n = 1) (Table 2).

Table 2
Demographical, socioeconomical and clinical profile of patients admitted due to PCSC who acquired HAI. Brazil, 2018.

Patients	ICD-10 PCSC	*Other comorbidities*	HAI	Etiologic agent	Schooling Years	Family Income (USD)*
Female **69 years**	Other urinary tract disorders	*Systemic lupus erythematosus, Arthritis, Non-dialytic renal disease*	CLABSI	carbapenem-resistant *Acinetobacter baumanni*	5	618.52
Male **79 years**	Insulin-dependent diabetes mellitus – with peripheral circulatory complications	*Diabetes mellitus*	Osteomyelitis	MRSA	14	259.34
Male **80 years**	Insulin-dependent diabetes mellitus – with peripheral circulatory complications	*Diabetes mellitus*	Osteomyelitis	MRSA	14	259.34
Male **50 years**	Unspecified bacterial pneumonia	*Diabetes mellitus and Chronic obstructive pulmonary disease*	CLABSI	*Salmonella* spp	4	389.22
Male **70 Years**	Serious protein-calorie malnutrition, unspecified	*None*	UTI	*Citrobacter freundii* complex	11	495.09

* Reference: December 2018: USD 1 = R$3.856 (at the time of the study)

Note: PCSC: Primary Care Sensitive Conditions; HAI: Healthcare-Associated Infections; MRSA: Methicillin Resistant Staphylococcus aureus; CLABSI: Central Line Associated Infections; UTI: Urinary Tract Infection.

There were no relevant differences regarding demographic and socioeconomic variables (both at individual level and city level) when comparing patients with or without HAI.

In the univariate analysis, PCSC were not associated with HAI (OR: 3.09; 95% CI: 0.914–8.183; p = 0,07).

The result of the multilevel regression analysis adjusted for the Gini Index and MDHI as the first level did not confirm our hypothesis of association between the outcome of HAI and the PCSC, showing an odds ratio of 2.877 (CI 9%: 0.960–8.625) with p = 0.05 (Table 3).

Table 3
Multilevel regression model for outcome occurrence HAI and selected variables adjusted by Gini Index. Brazil, 2018.

Variable	Adjusted by Gini Index		
	OR	95% IC	p-valor*
Sex	2.0758	0.957–4.498	0.06
Family income (average)	1.000	0.999-1.000	0.83
Charlson index	1.0816	0.909–1.286	0.37
PCSC	2.8778	0.960–8.625	0.05
Use of invasive medical device	5.0654	2.128–12.052	**< 0.001**
ICU	1.1039	0.464–2.626	0.82
* Exact Fisher Test p < 0.05			
Note: HAI: Healthcare Associated Infection; PCSC: Primary Care Sensitive Conditions; ICU: Intensive Care Unit.			

In the analysis of the nested case-control study based on propensity score balancing, the sample consisted of 62 participants. The group with PCSC had an odds ratio of 1.795 (95% CI 0.390–8.270) for the presence of HAI, but without statistical significance (p = 0.707) (Table 4).

Table 4
Association between HAI and PCSC in the nested case-control study using controls balanced by the propensity score. Brazil, 2018.

Primary Care Sensitive Conditions	Healthcare-Associated Infection			
	Yes (n = 31)		No (n = 31)	
Yes	3	9.7	5	16.1
No	28	90.3	26	83.9
Total	31	100	31	100

Discussion

In middle and low-income countries, HAI rates are higher when compared to high-income countries. These differences are mainly related to poverty, lack of basic sanitation and hygiene, lack of adequate equipment, and infrastructure, all of which are associated with the vulnerability of the population involved [1, 4].

However, few studies deeply investigate the potential association of non-biological factors, such as income, education or access to primary care, with HAI acquisition and antimicrobial resistance [8, 9, 10]. In this study we seek to understand the role of hospitalization due to PCSC as a risk factor to HAI.

Our hypothesis was that PCSC could be a marker of social vulnerability leading to unfavorable outcomes during hospitalization. The rationale for this hypothesis is that patients admitted due to PCSC have a history of failures in the effectiveness of primary care, thus accumulating comorbidities, and may be under social deprivation.

Nevertheless, in our casuistic we did not find an association between hospitalizations due to PCSC and acquisition with HAI.

Despite lack of association, our results demonstrated that this phenomenon needs to be better explored. In the group of patients with hospitalizations for PCSC who presented HAI, we observed some noticeable characteristics such as ageing, previous comorbidities, and retirement from work with low monthly family income. Studies indicated that higher rates of re-admissions, mainly in emergency services due to the presence of multiple comorbidities, characterizes some degree of complexity of the population that is hospitalized [11, 12, 13]. This phenomenon may be associated with a counter-transition demographic model, in which advancing population ageing and epidemiological change occur, with an increase in chronic non communicable diseases and climatic diseases, but still with a high incidence of infectious diseases [14, 15, 16].

Among the comorbidities of the studied population, diabetes was very common. Jeon (2014) [17] points out the presence of this comorbidity in both the population with community infections and HAI. In a recent systematic review of the risk factors for the presence of HAI, the presence of diabetes showed an independent risk factor for the presence of HAI (relative risk of 1.76; 95% CI, 1.27–2.44) [18].

Other studies demonstrated the influence of some social determinants of health, such as income, education, and housing on the occurrence of other infectious diseases and on re-admissions for chronic and acute diseases [19, 20]. Our study did not identify socioeconomic factors associated with HAI, although the group of patients hospitalized due to PCSC who acquired HAI had slightly (non-significant) lower monthly family income when compared to the group without HAI.

Other studies conducted in the UK in a single cardiology center explored the influence of non-biological issues, such as income and education, and have demonstrated higher risk of presenting surgical site infection for methicillin resistant *Staphylococcus aureus* among the group of patients from the most disadvantaged socioeconomic areas [21]. In a study conducted by Packer and colleagues (2015) [22] in Scotland it was found a possible association in the group of patients from regions with higher indices of social deprivation and the prevalence of HAI.

The findings from the literature highlights the need to investigate the influence of these factors for HAI, mainly in countries with greater social inequalities, with probable overlapping of social deprivation, failures in access to primary care, and lack of good structure for the implementation of HAI prevention and control

programs [23]. In our casuistic, at least five HAI cases could have been avoided if patients received efficient care at primary level.

Among the limitations of our study, the actual HAI rate was lower than expected during the sampling procedure and may have contributed to reducing the power of sampling and the non-confirmation of the research hypothesis. Also, around 50% of the participants came from the city of São Paulo, and the use of broad socioeconomic indicators (MHDI and Gini index) could be not enough discriminatory for socioeconomic vulnerability in a city that has an unequal distribution of wealth, with several spots of poverty. This study was performed in a tertiary hospital that received referred patients, which may have jeopardized the results.

We conclude that, are still unclear if and how much the HAI rates are influenced by vulnerability conditions such as preventable hospitalization by primary care. However, our study brings contribution for the planning and direction of public actions and policies for the reduction of PSCS and the prevention and control of HAI. The complexity of this phenomenon may require new methods and study designs may to fully capture and understand the impact of primary care in reducing the burden of HAI in the population.

Abbreviations

CLABSI
Central line-associated bloodstream infection
HAI
Healthcare Associated Infection
ICU
Intensive Care Unit
MHDI
Municipal Human Development Index
MRSA
Methicillin Resistant *Staphylococcus aureus*
PSCS
Primary Care Sensitive Conditions

Declarations

Ethics declarations

Ethics approval and informed consent to participate

The Research Ethics Committee of the School of Nursing, University of São Paulo and Hospital Clinics (process number CAAE 77965317.9.0000.5392 and CAAE 77965317.9.3001.0068, respectively) approved this project. The research was conducted following the instructions of resolution 466/2012 of the National Health Council. All participants signed the informed consent to be included in the study.

Consent for publication

Not applicable.

Availability of data and materials

Data are available under request to the corresponding author.

Statement along with approval statement

All methods were carried out in accordance with relevant guidelines and regulations.

Competing interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Contributions

EEP and MC designed the study, performed data analysis, and critical review of the manuscript. EEP was responsible for data collection and drafting the manuscript. TG contributed to the study design and critical review of the manuscript. JIDF contributed to the study design, statistical performing and data analysis. All authors have approved the submitted version of the final manuscript.

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