INSTITUTO UNIVERSITÁRIO EGAS MONIZ

MESTRADO INTEGRADO EM CIÊNCIAS FARMACÊUTICAS

HEALTHCARE-ASSOCIATED INFECTIONS: IS PORTUGAL HOMOGENEOUS?

Trabalho submetido por
Sofia Farinha Vieira Miranda
para a obtenção do grau de Mestre em Ciências Farmacêuticas

dezembro de 2020

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Prof. Doutor Duarte Pedro de Sousa Tavares

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Resumo

Introdução: Segundo o ECDC, é estimado que 3,1 milhões de pessoas, anualmente, contraiam Infeções-Associadas aos Cuidados de Saúde (IACS). Em 2016-2017, Portugal teve uma prevalência destas infeções de 9,1%, a segunda maior na Europa. Não obstante este resultado preocupante, não existem estudos que permitam verificar a existência de diferenças intranacionais nos hospitais portugueses.

Objetivo: O objetivo principal deste estudo é verificar se a prevalência de IACS é homogénea entre os hospitais públicos portugueses, e se for encontrada uma falta de homogeneidade, este estudo irá identificar que fatores influenciam esta variação.

Metodologia: Foi realizada uma a análise dos dados da base de dados administrativa do ECDC relativo ao Estudo de Prevalência de Ponto de Infeções associadas aos Cuidados de Saúde de 2016/2017 em meio hospitalar. Esta baseou-se na realização do teste do qui-quadrado para verificar a homogeneidade da prevalência de IACS entre hospitais e, posteriormente, foi desenvolvido um modelo de regressão logística que permite identificar, através de proxy, quais os fatores que influenciam esta variação e seu respetivo peso.

Resultados: Este estudo analisou 17,419 utentes de 82 hospitais públicos portugueses, onde cerca de metade dos pacientes eram do sexo masculino (51.4%) e a idade média era cerca de 61 anos. A maioria dos pacientes tinham um PVC (65.1%), e grande parte dos doentes tinha McCabe Score não fatal (70.2%). Os hospitais analisados eram maioritariamente hospitais secundários (37.8%).

Conclusões: Os dados analisados neste estudo mostram que há diferenças estatisticamente significantes entre as taxas de infeção nos hospitais em estudo. Os fatores com maior impacto na prevalência de IACs são a exposição a procedimentos invasivos, enquanto, pacientes masculinos e o número de FTE enfermeiras de controlo da infeção diminuem a probabilidade de infeção.

Palavras-Chave: Infeções-Associadas aos Cuidados de Saúde, Fatores de risco, Hospitais públicos portugueses, Estudo de Prevalência de Ponto do ECDC.

Abstract

Introduction: According to the ECDC, it is estimated that 3.1 million people, per year, acquire a Healthcare-Associated Infections (HAIs). In 2016-2017, Portugal had a prevalence of these infections of 9.1%, the second greatest prevalence in Europe. Despite this worrying result, there are no studies to verify the existence of intranational differences in Portuguese hospitals.

Objetive: The main goal for this study is to ascertain if the prevalence of HAIs is homogeneous throughout Portuguese public hospitals, and if there were found a lack of homogeneity, this study will also identify which factors influence this variation.

Methods: An analysis of the data from the ECDC administrative database was carried out regarding the Point-Prevalence Survey of HAIs in 2016/2017 in a hospital setting. This was based on the performance of the chi-square test to verify the homogeneity of the prevalence of HAIs between hospitals and, subsequently, a logistic regression model was developed that allows to identify, through proxy, which factors influence this variation and its respective weight

Findings: This study analysed 17,419 users from 82 Portuguese public hospitals, where about half of the patients analysed were male (51.4%) and that the mean age is around 61 years old. The majority of the patients had a PVC in place (65.1%), and most of the patients had a non-fatal McCabe Score (70.2%). The majority of the hospitals analysed in this study were secondary hospitals (37.8%).

Conclusions: The data analysed in this study showed that there are statistically significant differences between the infection rates of the hospitals under study. The factors with the most impact in the prevalence of HAIs are the exposure to invasive procedures, whereas male patients and the number of FTE infection control nurses decrease the probability of infection.

Keywords: Healthcare-associated infections, Risk factors, Portuguese public hospitals, ECDC Point-Prevalence Survey.

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List of Abbreviations

ACSS - *Administração Central do Sistema de Saúde*

BSI - Bloodstream Infection (BSI)

DGS – *Direção-Geral da Saúde*

CABSI - Catheter-Associated Bloodstream Infection

CCU - Continuing Care Unit

CDC - Centers for Disease Control and Prevention

CDI - *Clostridium difficile* Infection

CVC - Central Venous Catheter

DALYs - Disability-adjusted life years

ECDC - European Centre for Disease Prevention and Control

E. coli – *Escherichia coli*

EV-NBI - Epidemiologic surveillances for Nosocomial Bloodstream Infection

EV-NICU - Epidemiologic surveillances for Infection Acquired in Neonatal ICU

EU/EEA/UK - European Union, European Economic Area and the United Kingdom

FPR - False Positive Rate

FTE - Full-Time Equivalent

GBS - Group B Streptococcus

HAI – Healthcare associated Infection

HAI-NET-CDI - Epidemiologic surveillances for *Clostridioides difficile*

HAI-NET-ICU - Epidemiologic surveillances at Intensive Care Units in adults

HAI-NET-SSI - Epidemiologic surveillances for Surgical Site Infection

HAP - Hospital-Associated Pneumonia

HELICS - Hospitals in Europe Link for Infection Control through Surveillance

ICCU - Integrated Continuous Care Units

ICU – Intensive Care Unit

LR – Logistic Regression

Neo - Neonatal Sepsis

P – Pneumonia

PNCI - *Programa Nacional de Controlo de Infeção*

PPCIRA - *Programa de Prevenção e Controlo de Infeções e de Resistência aos Antimicrobianos*

PPP - Public-Private Partnerships

PVC – Peripheral Venous Catheter

ROC - Receiver Operating Characteristic

SNS – *Sistema Nacional de Saúde*

SSI – Surgical Site Infection

TPR - True Positive Rate

UTI - Urinary Tract Infection

VAP - Ventilation-Associated Pneumonia

WHO – World Health Organization

YLD – Life Lost due to Disability

YLLs – Years of life loss

Chapter 1 – Introduction

According to the European Centre for Disease Prevention and Control (ECDC), it is estimated that 3.1 million people, per year, acquire a Healthcare-Associated Infections (HAIs) in the acute care hospitals of the European Union, European Economic Area and the United Kingdom (EU/EEA/UK)[1]. The prevalence of these infections in EU/EEA/UK countries varied in 2016-2017s from 2.9% in Lithuania to 10.0% in Greece, as shown in Figure 1. Portugal has the second greatest prevalence, with 9.1%[2].

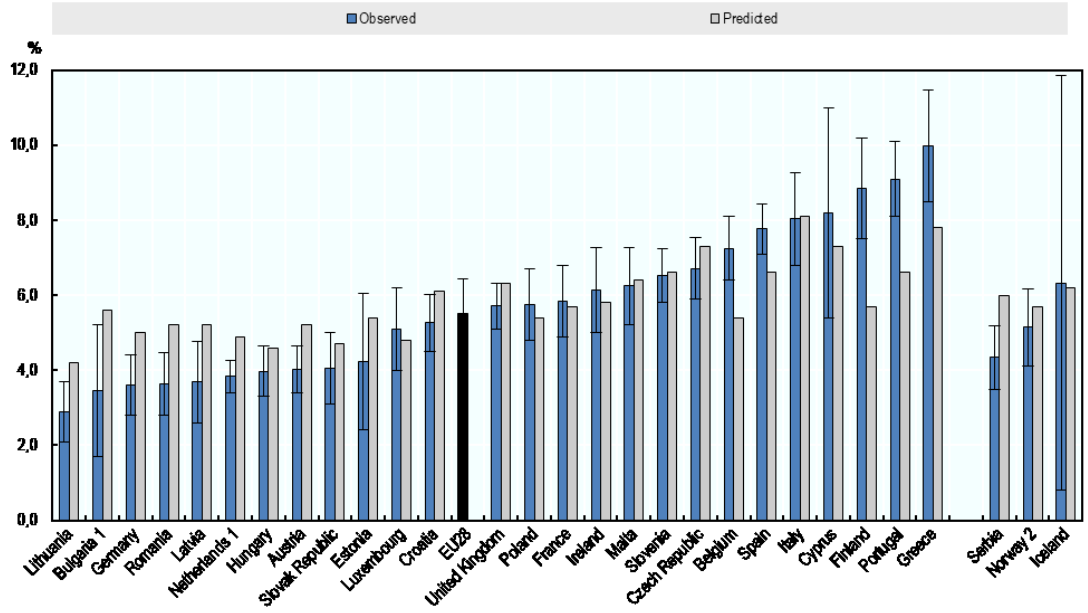

Figure 1 - Observed and predicted percentage of hospitalised patients with at least one healthcare-associated infection, 2016-17. Country representativeness of data is limited in Bulgaria and the Netherlands. Data from Norway includes partial imputation for missing types of infections. Note: 95% confidence intervals represented by H. Data for Denmark and Sweden are not available. The EU average includes Iceland and Norway[2].

Annually, it is estimated that 90,000 people die due to the six most common HAIs in Europe[3], and at least 20% of these infections are considered to be preventable[4].

Therefore, HAIs are a serious public health issue and currently represent one of the largest concerns of the health systems managers in Europe, especially when the life expectancy is increasing and elderly are more vulnerable to them[5]. Not only can HAIs affect the quality of care delivery, but also worsen the functional incapacity of the patients (decreasing their quality of life) and, in some cases, lead to death. On other hand, HAIs exponentially increase health care costs[5,6].

There are several factors that contribute to the appearance and growth of HAIs, notably the increasingly advanced age and prevalence of chronic diseases in hospitalized patients, the increasing use of invasive diagnostic and therapeutic procedures, overcrowded hospitals, patient's depressed immune system and the bacterial resistance[5,7]. It should be emphasised that the hospital's differentiation may also influence the HAIs prevalence, which is corroborated by the results from the European Point Prevalence Study on HAIs where primary/local hospitals had a lower prevalence (4.8%), when compared to secondary/regional hospitals (with 5,0%) and tertiary/central hospitals where the prevalence was 7.2%[8].

As stated before, Portugal has a high prevalence of HAIs when compared with other EU/EEA/UK countries and so it is of fundamental importance to ensure not only a continued registry of HAIs-related data, but also a deeper analysis and interpretation of that data[5]. Therefore, studies on this matter are important because they would provide the whole range of the dimension of the problem, as well as gather information on important factors, such as frequency, costs and geographical distribution, which can be helpful to set the priorities for possible future interventions[9] and to establish the national guidelines for infection control programmes[10].

Given that HAIs and resistance to antimicrobials are deeply related subjects, and should be approached in a global and integrated way, the *Programa de Prevenção e Controlo de Infeções e de Resistência aos Antimicrobianos* (PPCIRA) was created, in Portugal, with the goal to reduce both of their rates[11]. This programme is considered a priority health programme[12] and covers the various levels of provision of care and decision (local, regional and national) and establishes synergies with reference institutes, nationally and internationally. PPCIRA intervenes in different ways such as education, epidemiologic vigilance, standardization of structure, procedures and clinical practices and financial incentives through hospital financing[13,14] .

As one of the activities of the PPCIRA, Portugal participates in European epidemiological surveillance, having implemented two surveys of prevalence of infection, covering almost all hospitals and Integrated Continuous Care Units (ICCU) in the country. Furthermore, also coordinated by PPCIRA, Portugal established several epidemiologic surveillances at Intensive Care Units in adults (HAI-NET-ICU), Surgical Site Infection (HAI-NET-SSI) and for *Clostridioides difficile* (HAI-NET-CDI*),*within the scope of the European network, while surveillance for Nosocomial Bloodstream

Infection (EV-NBI) and Infection Acquired in Neonatal ICU (EV-NICU), take place within the national network[15,16].

Although Portugal has participated in several studies, the results published by *Direção-Geral da Saúde* (DGS), only show evidence on a global level of the country, not differentiating the results by region or hospital. These results should be a factor to take into account when financing hospitals, considering that the financial costs increase with the existence of HAIs, but currently this only happens in Public-Private Partnerships in *Loures* and, *Cascais* and until the end of 2020 also in *Vila Franca de Xira*[17].

Furthermore, there are no studies focused on the distribution of HAIs throughout Portugal. This study aims to identify the main HAIs in Portugal and assess its homogeneity throughout the country, comparing the 2016-2017s ECDC PPS incidence of main HAIs in each hospital using their administrative database for inpatient records. Additionally, if there were found a lack of homogeneity, this study will also identify the drivers of HAIs incidence and its weight based on mentioned administrative records.

Chapter 2 – Contextualization

2.1 Historical background

Diseases and illness have been documented throughout history and have had an important impact on human life, leading to social and political changes[18]. In particular, infectious diseases have always accounted for a very large proportion of the human diseases as a whole[19].

The hospital environment is, since its beginnings, a favourable place for the occurrence of infections[20,21]. It is possible to associate hospitals to high infection rates since medieval times, mostly because of the high number of epidemic diseases, the precarious conditions in which infected people were isolated, and the poor hygiene conditions[20,22]. Despite being a problematic subject over the centuries, it was only in the 19th century that hospital infections became a concern for healthcare professionals, being revealed the association between physician's poor hygiene and hospital infections[21,23].

In his book, *De contajione, ontagiosis morbis et curatine* (On Contagion, Contagious Diseases, and their Treatment), Girolamo Fracastoro (1478-1553)[24] proposed a revolutionary theory that infectious diseases were transmitted by minimal invisible particles from person to person[25,26].

Thomas Sydenham (1624-1689) shifted the clinical view and instead of trying to differentiate specific diseases, he focused on the individuals and their illness. This lead to the method of clinicopathologic correlation, first implemented by Giovanni Morgagni (1682-1771). A new way of thinking emerged, requiring careful clinic observation, differentiation, and specific diagnosis, and leading to the search for specific, rather than general, causes of illness[27].

With the expansion of careful clinical observation of individuals, epidemiologists in the 19th century were able to observe unusual epidemics and perform controlled studies to exposed individuals. Epidemiologic theories about the means of transmission of various infectious diseases often preceded the laboratory and clinical studies of the causative organisms[27].

In 1847, Ignaz Semmelweis (1818-1865)[28], known as the "father of infection control", identified high maternal mortality rates associated with puerperal fever after a few days

of delivery in patients seen by physicians compared to those seen by midwifes[29]. He also verified the death of a pathologist by sepsis after having suffered a cut by a scalpel, during an autopsy of a patient with puerperal fever, developing symptoms similar to those of women with puerperal sepsis[23,30]. From his observations, Semmelweis developed the hypothesis that infectious pathologies were due to the transfer of microorganisms through the scalpel and through the contaminated hands of physicians and students to patients in labour. Consequently, Semmelweis made hand washing with chlorinated solution mandatory for all physicians, medical students and nursing staff prior to the care of pregnant women, resulting in a sharp drop of maternal mortality rates by puerperal fever [23,29,30].

Semmelweis was the first to describe HAIs and to demonstrate that infectious diseases could be acquired in medical facilities[30] and is also important to refer that Anton van Leeuwenhoek (1632-1723) was the first to observe microorganisms describing how bacteria were present in several materials such as rainwater and human excretions[31].

In 1857, Louis Pasteur (1822-1895) demonstrated the dependence of fermentation on microorganisms, and showed that these organisms came from similar organisms present in the air. And finally, Robert Koch (1843-1910) proposed the "Henle-Koch postulates" to prove that a microorganism was the cause of an infection disease[27].

On the other hand Florence Nightingale (1820-1910)[32] described in 1863, procedures of care related to patients and the environment, with the intent to decrease the risks of hospital infection. Florence had the nurses to keep a system of reporting hospitals deaths, intending to evaluate the service. This was probably the first reference to epidemiologic survey[23].

At the beginning of the 20th century, there were already important contributions to the study of hospital infections, their epidemiology and their prevention. In 1928, Alexander Fleming (1881-1955)[33] observed that the *Penicillium notatum* fungi inhibited the growth of some bacteria and discovered penicillin[23].

As a consequence of this findings, many investments were made in the search for microbial contamination control measures. In 1865, Joseph Lister (1827-1912)[34] was concerned with the possibility of infections in his surgeries and invested in hand washing and disinfection of the surgical field[22]. Still in the 19th century, Von Pettenkofer (1818-1901)[35] pointed out the existence of individual susceptibility and the

influence of the environment in the development of diseases. Pettenkofer elaborated that there were other factors contributing to the installation of an infectious process, emphasizing the interaction of the agent, the host and the environment[23].

With the success of penicillin, an urge to produce other antibiotics grew and since then there was a big expansion of antibiotics over the course of many generations[23,36]. The success of antibiotics was impressive[36], which led to an unrestrained and inappropriate use of antibiotics with ever growing action. As a consequence of this irrational use there was an increasing number of infectious agents that acquired resistant to the antibiotics[22,37]. Consequently, it has become more difficult to treat some serious infections, forcing doctors to resort to second or third line therapeutic alternatives when the first treatment does not work, which lead to an increase of HAIs[19,36,38].

2.2 Types of healthcare associated infections

The Centers for Disease Control and Prevention (CDC) defines HAIs as a localized or systemic infection that results from an adverse reaction to the presence of an infection agent(s) or its toxin(s) that can be detected during hospitalization. Any infection already present or incubating at the time of the patient's admission must be excluded from this definition[39]. These infections were previously known as nosocomial infections but this designation excluded the ambulatory. Given that these infections can occur in hospitals, long-term care facilities, ambulatory settings and may also appear after the patient discharge, the concept of HAIs is more comprehensive as it includes all healthcare units as well as the ambulatory[5,40,41].

In addition to the definition of HAIs, there was also a need to identify these infections according to their location on the human body (for example urinary or pulmonary infection). This was made possible by the use of criteria adapted from those published by CDC or international conferences[42,43] which are based on clinical and biological factors, and include approximately 50 local hazard of infections[7].

Those can be aggregated into two types of risk factors that contribute to the increase of HAIs, intrinsic and extrinsic factors. Immunosuppression and prematurity belong to the first group; the second group includes the presence of peripheral venous catheter (PVC), surgery, urinary catheter, parenteral feeding and mechanical ventilation[38].

The six more common HAIs in Europe are urinary tract infection (UTI), primary bloodstream infection (BSI), neonatal sepsis (Neo), *Clostridium difficile* infection (CDI), surgical site infection (SSI), and pneumonia (P)[3].

UTI can be symptomatic or asymptomatic bacteriuria[44]. An asymptomatic bacteriuria is defined when a urine sample is collected from a patient without clinical signs and a certain amount of bacteria is isolated[45]. In UTI the clinical symptoms are: fever (>38ºC), urgency in urination, polaquiuria and dysuria or supra-pubic hyperesthesia[44].

There are three mechanisms that can lead to the increase of an UTI: the colonization through the catheter's lumen when it is removed from the collective bag, the colonization of the urinary meatus by bacteria from the gastrointestinal tract and the colonization from a remote location. The latter occurs in bloodstream infections by *Staphylococcus aureus*[46,47].

UTI is more prevalent in women, elderly, pregnant women, individuals with diabetes and individuals with a permanent catheter in the bladder[48]. UTI are associated with lower morbidity than other HAIs, but occasionally lead to bacteraemia and death[7].

Bloodstream infections are characterized by the presence of microorganisms in a blood culture[49]. The most common bloodstream infection is related to the presence of a peripheral vascular catheter; this is called a catheter-associated bloodstream infection(CABSI)[50].

In the last 60 years, the use of vascular catheters has become a very common clinical practice for several purposes. Out of these purposes, hemodynamic monitoring, haemodialysis nutritional support and medication administration stand out[49].

CABSI may occur due to the colonization of the device or due to contamination of the solution administrated by the device[51]. It can also be related to the colonization of the outer area of the catheter where de microorganisms originate either from the cutaneous flora or the internal colonization of the central vascular catheter[52].

Clostridioides difficile is an anaerobic, gram-positive bacterium. Generally fastidious in its vegetative state, but still it is capable of sporulating even when environmental conditions no longer support its continued growth. This enables the organism to persist in the environment for extended periods of time. A CDI can cause diarrhoea and colitis, but most patients remain asymptomatic after infection, while the bacteria continues to be shed in their stools[53,54].

Environmental contamination by C. *difficile* is well known, especially in places where faecal contamination may occur[55]. Even though a CDI is easily spread by direct exposure to contaminated patient-care items (e.g. rectal thermometers) and high-touch surfaces in patients' bathrooms (e.g. light switches)[56–58], the transfer of the pathogen to the patient via the hands of healthcare professionals is thought to be the most likely mechanism of contamination[54,59,60].

Neonatal sepsis can be caused by organisms associated with early-onset sepsis or late-onset sepsis. The first group includes Group B streptococcus (GBS), a gram-positive encapsulated bacteria that is one of the leading causes of neonatal sepsis and meningitis, and *Escherichia coli* (E.coli), a gram-negative bacteria that is a major pathogen in neonatal sepsis in preterm infants[61]. The second group is mainly associated with the organisms acquired from the environment after birth, such as *Pseudomonas aeruginosa*, *Candida albicans*, *Serratia marcescens* and E.coli[62,63].

The signs and symptoms of Neo are nonspecific[64]. While term newborns are more likely to have a fever, preterm newborns are more likely to react to the infection with hypothermia, because of transitional difficulty with temperature control specially in the first days[65,66]. On the other hand, the use of incubators might contribute to the lack of clinical relevance of body temperature in diagnosing sepsis later in preterm infants[67].

There is a rapid clinical deterioration unless a prompt antibiotic management in neonates with sepsis is started. Neo can be complicated by metastatic foci of infection, disseminated intravascular coagulation, congestive heart failure and shock[68].

Surgical site infections fall into three types: superficial incisional, deep incisional and organ or space[44]. A superficial incisional infection occurs within thirty days after surgery and affects only the skin and subcutaneous tissue at the incision site. A deep incisional infection may appear within thirty days after surgery without a prosthesis or within one year in case there is a prosthesis placement, and reaches the deep soft tissues of the surgical incision. An organ surgical infection appears within thirty days after surgery in case an implant is not used or within a year if an implant is used, and there must be an abscess or another evidence involving an organ[44,69].

The contamination of the surgical wound can have two origins, endogenous or exogenous. It is said to be endogenous when bacteria originate in the patient himself

and exogenous when the bacteria are foreign to the patient, originating in the surgical team, medical devices, surfaces, equipment and air[69].

Patients who acquired a SSI are 60% more likely to go to an intensive care unit, five times more likely to be readmitted and twice more likely to die, than patients with other HAIs[70].

Pneumonia is an inflammatory process developed in response to the microbiological invasion of the lung parenchyma. The severity of the response depends of the virulence of the pathogen and the patient's immune system. The host's innate defense mechanisms include air filtration and humidification in the upper airways, antimicrobial agents in saliva, reflective cough and mucociliary clearance[71,72]. It is possible to find in the terminal bronchioles the cellular and humoral response of the immune system that are also defense mechanisms. Generally, in intensive care units patients have their defense mechanisms weakened and, as soon as the microorganisms reach the sterile area of the lower respiratory tract, they multiply and lead to the development of pneumonia[72,73]. This pneumonia is classified as hospital-associated pneumonia (HAP), being the most common type of pneumonia in intense care units[74–76].

HAP is characterised by an infection of the lunges, caused by bacteria, viruses or fungi, which occurs within 48 hours after hospital admission in a patient who does not require mechanical ventilation[73]. When a patient with pneumonia requires ventilation it is called ventilation-associated pneumonia (VAP).

VAP is defined as pneumonia that appears over a period of more than 48 hours after the endotracheal intubation and mechanical ventilation[75]. There are two types of VAP, one that has an early onset (occurs between 48 to 72 hours after tracheal intubation) and one that has a late onset (occurs 72 hours after tracheal intubation). Normally, VAP with an early onset is due to microorganism sensitive to antibiotics, and VAP with a late onset is due to microorganism resistant to antibiotics, the latter is associated with increased morbidity and mortality[77,78].

2.3 Infection Rates in Portugal

The first two national studies on the prevalence of HAIs (referred to as nosocomial infections ate the time), in 1989 and 1993, reinforced the importance of epidemiological

surveillance, however these studies had important methodological differences regarding the selection of participating hospitals, inclusion criteria, data collection methods, among others[79].

Considering the relevance and the differences previously described, in 1998, the Council and the European Parliament set up a network for epidemiological surveillance and control of communicable diseases in the then European Economic Community, now the EU, and it was determined that each Member State should make efforts to integrate these European programs, although they can develop others at national level[80].

One of examples was the expansion of the existing Hospitals in Europe Link for Infection Control through Surveillance (HELICS) program so that all countries of the European Union could have implemented the same methodologies for epidemiological surveillance of HAIs, which Portugal adhered[15].

The Infection Prevalence Survey Report, in 2003, by *Programa Nacional de Controlo de Infeção* (PNCI) was the first in Portugal to be carried out with the HELICS protocol. This study analysed 16,373 patients from 67 hospitals, the prevalence of infections was 9.9% and the risk factors identified were the age of the patient and the length of stay in the hospital[79].

Portugal joined, in 2008, the World Health Organization's (WHO) Hand Hygiene Campaign with the aim to reducing 5% of HAIs[15]. However in 2009 PNCI performed another National Infection Prevalence Survey, design to determine the prevalence of HAIs and their distribution by topography, microorganisms and their susceptibilities to antimicrobials. Through this study, carried out on 21,459 patients from 114 hospitals (public and private), was obtained a prevalence of HAIs of 11.0%. The predominant locations of these infections were respiratory and urinary tract. It was in patients aged over 60, especially over 79, that the highest infection rates were seen. This study allowed a comparison with the results obtained in the 2003 study and made it possible to assess the impact of the Hand Hygiene Campaign, concluding that it was necessary intensify surveillance and implement more effective infection prevention and control measures[81].

In 2010 PNCI carried out another Infection Prevalence Survey Report, with the same protocol and objectives as the previous study. This report involved 21,011 patients from

97 hospitals, both public and private, and the prevalence of HAIs was of 11.7%, no comparisons were made with the previous studies[82].

At the time of this study, Portugal was already in several epidemiologic surveillances at HAI-NET-ICU and HAI-NET-SSI, however these units continued to be at higher risk of infection, reinforcing once again, the need to a continuous participation in programs and develop intervention for the reduction of HAIs in these units. This study also addressed the need for a specific approach to the high rate of infection in paediatrics, as well as a need for an intervention project for BSI due to its high morbidity and mortality associated[82].

Given the aforementioned need, between 2010 and 2013, epidemiological surveillance studies of BSI were carried out annually, with an online registration[83–86]. This program had existed, at the time for 10 years, in order to allow the definition of reference values for hospitals to be able to compare their performance with national data. However, the 2010 study was the first of this new phase of the program[83].

These studies calculated the cumulative incidence of BSI, defined as the proportion of infection per 100 patients admitted; the incidence density of BSI corresponding to the number of infections per 1000 days of admission; the incidence of BSI associated with Central Venous Catheter (CVC), *i.e.* the number of infections for 1000 days of exposure to this device; crude mortality rate in BSI patients; and other risk factors considered relevant at the time[83–86].

Table 1 shows that the number of hospitals participating in these studies has increased over the year, with the participation of about half of Portuguese hospitals in 2012 and 2013, which consequently increased the number of patients analysed. It is verified that incidence density of BSI and the incidence of BSI associated with CVC decrease slightly in the first years, and ultimately maintained similar values. The proportion of infection decreases slightly in each study done, while in contrast, the crude mortality rate increases[83–86].

Survey Year	Hospitals analysed	Patients analysed	Infection per 100 patients	Infection per 1000 days of admission	Infection per 1000 days of exposure to CVC	Crude Mortality Rate
2010	19	118,037	1.2	1.5	2.5	28.1%
2011	43	266,425	0.87	1.2	2.2	29.1%
2012	54	301,644	0.88	1.2	1.9	29.2%
2013	51	329,253	0.84	1.2	1.9	30.5%

Table 1 – Summary table of the results obtained from the epidemiological surveillance studies between 2010 and 2013.

However, the gross mortality rate of BSI associated with CVC, considered preventable infections, decreases considerably between 2010 (17.3%) and 2013 (9.8%)[83,86].

With the better adherence of hospitals to these studies, it was possible to better understand the national panorama regarding BSI, allowing PNCI to identify which areas are in greatest need of intervention[85].

In 2012 PNCI carried out a national study on prevalence of HAIs and the use of antibiotics in Continuing Care Units (CCU) and in 2013, ECDC carried out a "Healthcare-Associated Infection and Antimicrobial Use in Long-Term Care Facilities" survey at European level, derived from the aging of the population, which consequently increased the need for treatment in CCUs. The prevalence of HAIs calculated in the first study was 8.1% and in the latter 11.3%. However these results cannot be directly compared as changes were made to the definitions of urinary tract infections[87,88]. Nevertheless the results from the ECDC study can be explained, among other reasons, due to the fact that many UCCs did not have a healthcare professional responsible for the prevention and control of infection[88].

Regarding the prevalence of HAIs in hospitals, two European studies were also carried out in 2012 and 2013, where it was found that infection rates in Portugal were 10.8% and 10.4%, respectively[89,90].

In 2014, already within the scope of PPCIRA, the Hand Hygiene Campaign was extended to other components of basic precautions in infection control, as this was considered the most efficient, simple and economical measure to prevent HAIs[15,91]. Recent PPCIRA studies show that between 2011 and 2017, more and more Portuguese hospitals have been adhering to the monitoring of practices of basic precautions in infection control[15,89].

The most recent Point prevalence survey of HAIs in acute-care hospitals and UCC, in 2016-2017, showed that that the prevalence of HAIs in Portugal was 9.1%, as indicated in chapter 1 of this study[1].

Over the decades, it is possible to verify a variation in the prevalence of HAIs. The increased prevalence of these infections between 2003 and 2012 can be explained by an increase in the number of hospitals participating in these studies and by differences in the definitions of HAIs[15,87,89]. Nevertheless, in more recent years there has been a trend towards a decrease in the prevalence of HAIs, as can be seen in table 2[89].

Year	Prevalence of HAIs
2003	9.9%
2009	11.0%
2010	11.7%
2012	10.8%
2013	10.4%
2017	9.1%

Table 2 – Summary table of the results obtained from National and European Infection Prevalence Survey Reports between 2003 and 2017.

The studies and reports related to this theme, have been an asset in understanding the global and Portuguese panorama, in particular. This knowledge allows us to better identify not only the areas most affected by HAIs, but also the risk factors for these infections that need more attention by the healthcare professionals[15,89].

2.5 Risk factors for HAIs

When hospitalized, the likelihood of HAIs increases[40]. To better understand the possible differences between hospital's HAIs prevalence rates, it is necessary to understand what can lead to such differences. The emergence of HAIs is determined by patient-related and hospital-related risk factors depending on medical interventions, staff, patient's condition, and other reasons[92].

2.5.1 Patient-related risk factors:

Several researches showed that there is a statistically significantly higher prevalence of HAIs among males compared with females[93–95]. Regarding the patient's age, the highest prevalence of HAIs is usually observed in children with less than five years of age and in adults over sixty-five years of age[94–97].

There is a high correlation between the prevalence of HAIs and the patient's exposure to invasive procedures, such as intravascular catheter, intubation, mechanical ventilation, and urinary catheter[92,94,95,98,99]. This can be related to the comorbidity between patients carrying the device and the greater possibility of entry of pathogenic organisms in these patients, therefore causing the infection[100].

The differences in HAIs prevalence can also be explained by the patient's stay in the hospital: stays longer than 14 days, patients admitted to Intensive Care Units (ICUs), and patients who underwent surgery since admission are associated with a higher prevalence of HAIs[92,94,98,101].

Patients' prognosis during hospitalization is also considered a risk factor for HAIs[94]. One way to assess this prognosis is through the McCabe score. This score classifies all hospitalized patients, according to a prognosis, into three categories: Non-fatal (expected survival at of least 5 years), ultimately fatal (expected survival between 1 year and 5 years) and rapidly fatal (expected death within 1 year)[102,103]. The McCabe score was first developed base on observations of endotoxin tolerance in humans[104], currently it is used as a subjective – yet valid an reliable - score of underlying illness severity in HAI point prevalence surveys[102,103].

2.5.2 Hospital-related risk factors:

The hospital size is one of the several hospital-related risk factors to consider, bigger hospitals, i.e. with a larger number of rooms/beds, are associated with a higher HAIs' prevalence. The Hospital type may be related to the latter factor, and should also be included as a risk factor. Teaching hospitals, or secondary hospitals, have a higher prevalence of HAIs than specialized hospitals[94].

The hospital capacity of patients isolation is also one the risks to consider[94]. Different studies have showed that the number of beds per ward can differentiate the prevalence of HAIs - patients placed in single rooms have a lower incidence of HAIs than patients placed in shared rooms[105,106].

There is a significant evidence that high adherence to hand hygiene procedures is extremely important to reduce the prevalence of HAIs[107,108]. The proper procedure of hand disinfection is one of the most effective infection control measures, so providing hand rub dispensers in wards and/or patient rooms can be a contributing factor for hand hygiene compliance[109,110]. These hand rub dispensers are usually placed in wards walls or by the patient's bed. However, there is still no clear data to which location has a greater probability of being used by professional healthcare workers[110,111].

Analysing the workload of infection control staff several researches, measured by number of beds per Full-Time Equivalent (FTE) infection control doctors/nurses, indicated that the prevalence of HAIs is lower in hospitals with fewer beds per FTE infection control doctors/nurses[94,112,113].

Once a global review has been made that includes the most relevant topics, the methodological assumptions of the study will be defined in the next chapter.

Chapter 3 – Methodology

3.1 Study Design

This study intends to ascertain if there are significant differences in the prevalence of HAIs between NHS' hospitals units and to verify which factors influence their variation, comparing the annual incidence of HAIs in each hospital, based on the 2016/2017 ECDC Point Prevalence Study data. Therefore this is a correlational/epidemiological study, whose study population is the discharge diagnoses of 17,419 citizens hospitalized in 82 hospitals.

To do so:

- The variables considered relevant in the literature *i.e* the risk factors for the hospital's prevalence of HAIs, as explained in the previous chapter, were selected.
- A chi-square test was performed to verify the homogeneity of the prevalence of HAIs in hospitals.
- It was statistically calculated, through logistic regression, whether each selected variable has a significant correlation in the prevalence of HAIs.
- The results obtained were compared with the results attained in similar studies.

3.2 Data Source

To carry out this study, the data contained in the ECDC's HAIs Point Prevalence Study 2016/2017 administrative database for inpatient records, regarding Portugal, was used. This global administrative database contains the discharge diagnose informations of 21,339 patients in 125 hospitals, throughout the country.

For this study, there was no direct collection of primary data nor was any consultation of patients' clinical files. Also, there was no access to data that would allow the identification of the hospitalized citizen.

3.3 Exclusion Criteria

In this study only Portuguese public hospitals were analysed, therefore all private hospitals or public-private partnerships in the ECDC database were excluded.

Therefore, this study will analyse 17,419 patients from 82 Portuguese public hospitals.

3.4 Variables under Study

To study the correlation between risk factors and the prevalence of HAIs in each hospital, the variables analysed, in each hospital, were: hospital type, mean age of patients, litters of alcohol hand rub consumed per year, number of hand hygiene opportunities, number of beds, number of hospital discharges, number of patient's bed days, number of patients, number of patients staying in ICUs, number of FTE specialized infection control doctors or pharmacists per bed, number of FTE specialized infection control nurses in the hospital per bed. Were also analysed, in each hospital, the percentages of: female patients, patients with invasive procedures such as CVC, PVC, urinary catheters or patients intubated, the patients McCabe Score (either non-fatal, rapidly fatal or ultimately fatal), hospital beds with an alcohol hand rub dispenser, and patients that received at least one systemic antimicrobial agent.

The characteristics of each variable are described in table 3.

Name of variable	Description	Type of variable
Has HAI	Patients with at least on Healthcare-associated infection	Nominal Categorical Variable (1=Yes; 2=No or Unkonwn)
Hospital Type	Type of Hospital	Ordinal Categorical Variable (1=Primary; 2=Secondary; 3=Tertiary; 4=Specialist/Other)
Gender	Patient's Gender	Nominal Categorical Variable (1=Male; 2=Female)
CVC	Patients with Central Venous Catheter during intensive care unit stay	Nominal Categorical Variable (1=Yes; 2=No or Unkonwn)

Intubation	Patients intubated (invasive respiratory device) during intensive care unit stay	Nominal Categorical Variable (1=Yes; 2=No or Unkonwn)
McCabe Score	Patient's McCabe Score (non-fatal, rapidly fatal or ultimately fatal)	Ordinal Categorical Variable (1=NON-Fatal or Unknown; 2=RAPFatal; 3=ULTFatal;)
PVC	Patients with peripheral vascular catheter in place	Nominal Categorical Variable (1=Yes; 2=No or Unkonwn)
Urirany Catheter	Patients with an indwelling urinary catheter in place	Nominal Categorical Variable (1=Yes; 2=No or Unkonwn)
Mean age	Mean age of patients	Scalar Variable
Number of Infection Control Doctors FTE	Number of Full Time Equivalent specialized infection control doctors or pharmacists in the hospital	Scalar Variable
Number of Infection Control Nurses FTE	Number of Full Time Equivalent specialized infection control nurses in the hospital	Scalar Variable
Patient Days	Number of patient days (bed days) for the same year and the same wards as the yearly number of discharges/admissions	Scalar Variable

Table 3 – Description of the variables under analysis.

3.5 Statistical Analysis

In this study, the prevalence of HAIs in each hospital was considered as a dependent variable, and the variables indicated in table 3 were considered independent variables.

3.5.1 Verification of Homogeneity

For the verification of homogeneity of the prevalence of HAIs in the hospitals under study a chi-square homogeneity test was performed, with a significance of 5%.

To achieve this goal the softwares Microsoft Office Excel® 2013 and SPSS® version 26 were used, and the level of significance was 95%.

3.5.2 Study of the weights of each variable in the prevalence of HAIs

To meet the objective of this study, a proxy was defined: the weight of a patient being more likely to have HAI. This proxy leads us, indirectly, to have the response to the weight of each variable in the prevalence of HAIs.

For the study of the weight of each variable in the prevalence of HAIs a model with Logistic Regression (LR) was developed.

LR is an effective classification method for dichotomous response variables, as well as for describing and testing hypotheses about relationships between a categorical outcome variable and continuous predictor variables The probability of an event occurring (in this case, having at least on HAI) is estimated by adjusting the data to the logistic curve[114,115].

LR is based on the fundamental mathematical concept, *logit.* Which is the natural logarithm of the odds ratio, meaning, the ratio between the probability of the occurrence of an event (in this case, having at least on HAI) and the probability of the non-occurrence of the same event[114].

The logistic model has the form off the following equations:

$$\log\left(\frac{p}{p-1}\right) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n$$

Solving to *p*,

$$p = \frac{1}{1 + e^{-(\beta_0 + \cdots + \beta_n x_n)}}$$

Where *p* represents the probability of the event, β_i identifies the regression coefficients and x_i are the input variables, meaning the variables shown in table 3[114].

If $p \geq 0.5$, then the predicted class is Y= 1 (the patient has at least one HAI). Contrarily, if $p < 0.5$, Y = 0 (The patient does not have any HAI). From the previous equations, it is possible to verify that β_i coefficient increases the probability of Y = 1 and if the coefficient is negative, this probability decreases.

For this study a binary LR[114] was developed, using the binary response (No=0; Yes=1). All input variables using a α of 0.05 and an automatic variable selection process in SPSS based on the stepwise methodology were considered to determine the final and best model from LR. In the stepwise backward method, all variables are inserted in the SPSS. The variables that are not significant are removed, only remaining those that are. After the various iterations, a model with all the important variables is reached.

To evaluate the performance of this model, the Receiver Operating Characteristic (ROC) curve was used. ROC curves are a powerful visual tool that allows model comparison. These curves show, for a given model, the trade-off between the True Positive Rate (TPR), *i.e* sensitivity, and the False Positive Rate (FPR), meaning specificity. Where an increase in TPR is always accompanied by an increase in FPR. An area under the curve of 1 implies perfect discrimination whereas an area under the curve of 0.5 implies that the model is not discriminatory[116].

Chapter 4 – Results

4.1 Exploratory Analysis

The characteristics of each variable introduced as independent are shown in tables 4 and 5. Categorical variables were expressed as percentages, while scalar variables were expressed as averages.

		Frequency	Percentage	Valid Percentage	Acumulative Percentage
Has HAI	NO/Unknown	15,803	90.7	90.7	90.7
	YES	1,616	9.3	9.3	100.0
	Total	17,419	100.0	100.0	
CVC	NO/Unknown	15,878	91.1	91.2	91.2
	YES	1,541	8.8	8.8	100.0
	Total	17,419	100.0	100.0	
Gender	Male	8,959	51.4	51.4	51.4
	Female	8,454	48.5	48.5	100.0
	Total	17,413	100.0	100.0	
Intubation	NO/Unknown	16,935	97.2	97.2	97.2
	YES	484	2.8	2.8	100.0
	Total	17,419	100.0	100.0	
McCabe	Non Fatal/Unknown	12,215	70.2	70.2	70.1
	Rap Fatal	1,069	6.1	6.1	76.3
	ULT Fatal	4,135	23.7	23.7	100.0
	Total	17,419	100.0	100.0	
PVC	NO/Unknown	6,085	34.9	34.9	34.9
	YES	11,334	65.1	65.1	100.0
	Total	17,419	100.0	100.0	
Urinary Cathter	NO/Unknown	13,642	78.3	78.3	78.3
	YES	3,777	21.7	21.7	100.0
	Total	17,419	100.0	100.0	
Hospital Type	Primary	22	26.8	26.8	26.8
	Secondary	31	37.8	37.8	64.6
	Tertiary	19	23.2	23.2	87.8
	Specialist/Other	10	12.2	12.2	100.0
	Total	82	100.0	100.0	

Table 4 – Characteristics of the citizen analysed in the present study (I).

Descriptive Statistics					
	N	Minimun	Maximum	Average	Standard Deviation
Age	17,419	0.00	106.00	60.79	24.37
Number of Infection Control doctors FTE	82	0.00	7.00	0.93	1.56
Number of Infection Control Nurses FTE	82	0.00	32.00	2.09	4.16

Table 5 – Characteristics of the citizen analysed in the present study (II).

Related to the patient's risk factor, the analysis of table 4 shows that about half of the patients analysed are male (51.4%) and that the mean age is around 61 years old. Table 4 also indicates that the majority of the patients has a peripheral vascular catheter in place (65.1%), and most of the patients have a non-fatal McCabe Score (70.2%), meaning that they have an expected survival of at least 5 years.

Related to the hospital's risk factors, table 4 shows majority of the hospitals analysed in this study are secondary hospitals (37.8%), followed by primary hospitals (26.8%). While table 5 shows that the 82 hospitals analysed have an average of 2 FTE specialized infection control nurses per bed.

In table 4 it is possible to verify that 9.3% of the patients analysed had at least one HAI.

4.2 Verification of Homogeneity of the prevalence of HAIs

It can be verified, using the Chi-square test, that there are statistically significant differences between the infection rates of the hospitals under study, for a p-value of 0.05, since the value of the test statistic (597.88) is greater than the critical quantile value, namely around 124.34.

4.3 Factors that influence the rate of infection

Considering that knowing what increases the probability of having an infection in a citizen makes it possible to understand the variation in the rate of infection globally in a hospital. Table 6 shows the parameters of the logistic regression model calculated to understand the weight of each variable in the prevalence of HAIs.

	Regression coefficient (B)	Sig.	OR	95% C.I. for OR	
				Lower	Upper
Age	0.008	<0.001	1.008	1.005	1.010
CVC(1)	1.566	<0.001	4.789	4.099	5.596
Gender(1)	-0.191	0.001	0.826	0.741	0.921
Intubation(1)	0.474	<0.001	1.607	1.273	2.029
McCabe(1)	0.478	<0.001	1.613	1.352	1.924
PVC(1)	0.589	<0.001	1.802	1.576	2.061
Urinary Catheter(1)	0.589	<0.001	1.802	1.595	2.035
Hospital type(1)	0.194	0.012	1.214	1.043	1.413
Hospital Type(2)	0.205	0.009	1.228	1.053	1.432
FTE_Nurses	-0.018	0.050	0.982	0.965	0.999
Constante	-3.680	<0.001	0.025		

Table 6 – Results of linear regression of the variables in the equation

The results of the LR show that the statistical important isolated variables are the age of the patient, being male, being exposed to invasive procedures, namely CVC, PVC, urinary catheters or being intubated, having a non-fatal McCabe score, the type of hospital, in particular primary and secondary hospitals, and the number of FTE infection control nurses per bed.

For a better understanding of the results presented in table 6, it is important to note that the values that have a negative regression coefficient value lead to a decrease in the probability of having an infection, while the positive values increase this same probability. The higher the regression coefficient value, the greater the weight of this variable to increase the prevalence of HAIs.

Considering the above explained, table 6 shows that, from the considered statistically significant variables, there are two factors that have a negative correlation in the prevalence of HAIs: male patients and the number of FTE infection control nurses per bed. While the remaining variables in Table 6 show to be factors that lead to an increase of the probability of infection.

It can be seen that the variables with greater weight in the prevalence of HAIs are exposure to invasive procedures. Having the greatest weight the exposure to CVC, with a regression coefficient value of 1.566, followed by the exposure to PVC and urinary catheters, both with a regression coefficient value of 0.589.

The variable with the lowest impact in the probability of infection is the age of the patient, regression coefficient value of 0.008.

In order to validate the model developed for this study, the area under the Receiver Operating Characteristic (ROC) curve was calculated, having obtained a value of 0.734, whose 95%interval is [0.722-0.746], as shown in figure 2.

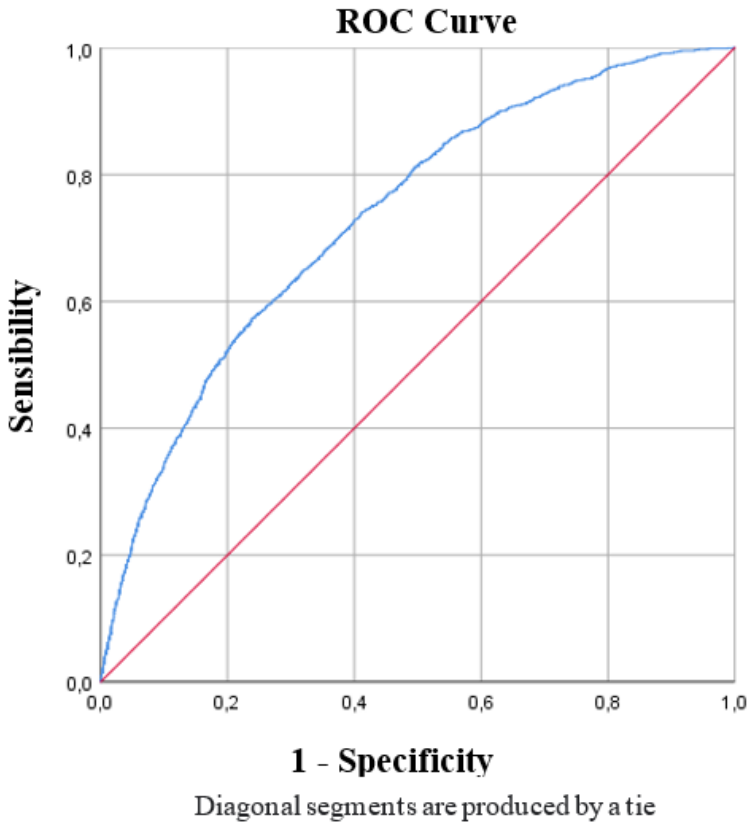

Figure 2 – ROC curve of the final logistic regression model

Chapter 5 – Discussion

The prevalence of HAIs calculated in this study was 9.3%, which is similar to the result from the 2016-2017 ECDC study (9.1%)[2]. Nevertheless it was possible to verify that there is no homogeneity between the prevalence of HAIs in Portuguese public hospitals.

It is important to emphasize that infections from ambulatory settings were not analysed in this study.

The results from this study shown that males had a higher prevalence of HAIs than females, which a common result that is consistent with the results from several studies[94,95,100]. However, in this study, there was a negative correlation between male patients and the probability of infection. This was an unexpected result, since it is contradictory to what is described in the literature, and requires further analysis.

There was a clear association between the prevalence of HAIs and the patient's exposure to invasive procedures, particularly in the case of CVC, which proved to be the factor with the greatest impact in the probability of infection, in this study. This was an expected result, considering that several studies have shown that the exposure to a CVC is highly correlated to HAIs[94,95,100,117].

In the cases of patient's exposure to intubation, PVC and urinary catheter it was also found a positive correlation. Such associations have been reported in several studies[94,95,100,118], reinforcing the need to ensure greater safety for the patient when performing or maintaining these procedures. A study in Spain shown a 50% decrease in catheter-related BSI in ICUs by limiting exposure and successful introduction of prophylaxis[119].

Regarding the McCabe scores, usually patients with a classification of rapidly fatal and ultimately fatal have a higher risk of HAIs, since these patients have more comorbidities[102]. In most studies these two groups are statistically correlated with a higher prevalence of HAIs[94,117,118]. However, some studies contradict this fact and show that non-fatal McCabe scores increase the probability of infection[100,120]. The latter results are corresponding with the results from this study, nevertheless the correlation of the three McCabe scores with HAIs probably needs to be further studied to reach a consensus on its impact on the prevalence of these infections.

Hospital type is not a common risk factor to be consider in studies of this nature, being rarely analysed[94]. Regardless this study shows that secondary hospitals have a better correlation with HAIs than primary hospitals, which is contradictory with the A. Deptula *et al* study, where even though the prevalence of HAIs was higher in secondary hospitals, its weight on the probability of infection was lower[94].

Despite being the risk factor with the lowest impact on the probability of infection, the age of the patient still had a positive correlation with HAIs. This correlation was shown in several studies[94,95,120]. However these studies analysed age classes, whereas in this study the mean age of the patients was analysed.

In the present study the number of FTE infection control nurses per bed proved to have a negative correlation with HAIs, meaning that decreased the probability of infection. A similar result was found in the A. Deptula *et al* study. However increased numbers of infection control staff has been associated with a higher prevalence of HAIs[112,113]. Further studies are needed in order to ascertain the optimal number of FTE infection control staff[94].

Nearly all the risk factors studied showed a significant positive correlation with HAIs, however this study did not found a correlation between a higher prevalence of HAIs and several commonly found risk factors. Some examples are the patient being admitted to surgery since admission, the patient being in ICU, and if the patient was receiving antibiotics[92,95,100].

Even though the use of a LR model to estimate the impact that some variables have in the prevalence of HAIs, and Chi-square test to ascertain the data's homogeneity is a methodology used in several similar studies[94,95,100]. The differences between this study and several other studies results can be explained due to possible differences in methodologies, in particular the definitions of HAIs used, and how and when the data was collected.

Another methodological difference is that all the data analysed in this study are reported at a simple descriptive level. Many of the risk factors studied can be inter-related, as several studies have shown[100,117]. However the main objective of this study was to observe and characterise a pattern of association between the prevalence of HAIs in different Portuguese hospitals, therefore a multiple regression model was not made.

As mentioned in chapter 3, in this study only Portuguese public hospitals were analysed, excluding both private hospitals and PPPs. This exclusion was made for a better comparison of data on the prevalence of HAIs in each hospital, given that private hospitals and PPPs have their own indicators for HAIs, which does not happen directly in public hospitals. Public hospitals only have these indicators in the quality component that affects only 10% of the annual budget.

This study has some limitations that should be pointed out. One is that some hospitals had incomplete clinical data, which may introduce bias in the statistical analysis. Another limitation is the fact that it was not possible to link the data referring to the patient's characteristics with the data referring to the type of HAI and in which ward the patient was hospitalized. These limitations decreased the study's ability to make a complete analysis of the factors that influence the prevalence of HAIs.

Despite the limitations above mentioned, this study showed an innovative view of the data regarding HAIs, namely on the comparison of the prevalence of infection in Portuguese public hospitals and what are the factors that cause these variations.

To better understand the impact of HAIs, it is necessary to study their burden of disease. Future studies on this matter could associate the lack of homogeneity in the prevalence of HAIs in Portuguese hospitals to ascertain which risk factors have greater burdens.

This can be achieve by calculating Disability-adjusted life years (DALYs) are a well-established methodology for estimating the burden of disease, that provides a common metric to aid meaningful comparison of the burden of risk factors, diseases, and injuries[121,122]. DALYs are calculated as a sum of years of life loss (YLLs) due to premature mortality and years of life lost due to disability (YLDs)[123].

This study is important for pharmaceutical sciences as its results show that there is a lack of homogeneity in the prevalence of HAIs, which is a concerning fact. This knowledge can contribute to the awareness of the importance of adopting evidence-based protocols and strict application of infection control guidelines that are similar throughout Portuguese Hospitals, aiming to create better infection control programs and, consequently, making hospitals safer for patients and healthcare professionals.

Chapter 6 – Conclusion

From this study it is possible to conclude that HAIs have been a public health problem over the years. Regardless, the prevalence rates of HAIs has been decreasing in recent years, possibly as a result of increasingly conducting more studies and campaigns on prevention and infection control.

However, these studies are carried out comparing hospitals as a whole, creating a failure to understand the differences in the prevalence of HAIs between the various hospitals

The main goal for this study was to ascertain if the prevalence of HAIs is homogeneous throughout Portuguese public hospitals.

In order to achieve such goal, it was necessary to assess several risk factor for HAIs, which may be related to patients and/or hospital characteristics, and understand which of these factors influence the rate of infections.

To achieve the objectives defined for this study the data from ECDCs 2016/2017 Point Prevalence Study administrative database for inpatient records was used. About 17,419 patients from 82 Portuguese public hospitals for the years 2017 and 2018 were analysed.

Regarding the risk factors for HAIS, first an exploratory analysis was carried out where it was possible to analyse the characteristics of the variables under study.

To determine which factors influence the rate of infections Linear Regression was used for the variables under study, a 5% significance level was considered. It is concluded that the variables that have a higher correlation with the prevalence of infections are the age of the patients, patients with non-fatal McCabe scores, patients exposed to CVC (this being the factor with the greatest weight in the prevalence of HAIs), PVC, intubation or urinary catheter, and primary and secondary hospitals. It was also concluded that the gender (male) of the patient and the number of FTE infection control nurses per bed had a negative correlation with HAIs, meaning that these factors decrease the probability of infection.

From this study it can be concluded that the prevalence of HAIs is not homogeneous throughout Portuguese public hospitals.

This study proves to be innovative, since it compares the prevalence of HAIs of several Portuguese public hospitals with the aim of analysing which factors cause the

differences between them. Rather than analysing this data as a group. The results from this study can contribute to the statement that HAIs still remain a public health issue, as well as a high burden for healthcare systems, threatening patient safety in hospitals, leading to high rates of morbidity and mortality and increasing healthcare costs.

It is expected that this study contributes to the understanding of the need for hospitals to adopt evidence-based protocols and strict application of infection control guidelines that are similar throughout Portuguese Hospitals, in order for better prevention of HAIs and to make them safer for both patients and healthcare professionals.

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