General Introduction

1.1 HOSPITAL-ACQUIRED INFECTIONS AND THEIR IMPACT ON HOSPITAL CARE

Hospital-acquired infections

Nosocomial infections, hospital acquired infections or currently called healthcare-associated infections (HAI) are the most common complications (adverse events) affecting hospitalized patients[1]. Per definition HAI are infections that develop during a patient's stay at a hospital and were not present or incubating at the day of admission. An infection is active when signs and symptoms of the infection are present on the survey date or if the signs and symptoms were present in the past and the resident is (still) receiving treatment for that infection on the survey date. Internationally the CDC/NHSN criteria[2] and in the Netherlands the ECDC/PREZIES criteria[3] for hospital acquired infections are adopted to standardize the scoring of HAI. Theoretically using the same definitions enables comparison of HAI rates between hospitals and even coutries, although challenges do exist[4]. There are criteria for over forty different specific types of hospital-acquired infections, grouped into thirteen categories. Urinary tract infection (UTI, mostly catheter-related), surgical site infection (SSI) , lower respiaratory tract infections (LRTI, including pneumonia as well as ventilator associated pneumonia (VAP)) and (central line-associated) bloodstream infections (CLA-BSI) together account for more than eighty percent of all reported nosocomial infections. These are therefore called "the big four".

Etiology of hospital-acquired infections

Hospitalized patients are often immunocomprimised because of underlying illness and treatment. Because essential parts of the innate and adaptive immune system are compromised by, for example, surgical interventions, intravascular devices, immune-suppressive treatment these patients are more susceptible to infection by micro-organisms including bacteria, viruses, parasites and fungi.

Endogeneous micro-organisms (i.e. the commensal flora of skin and intestines) account for approximately 50 percent of hospital-infections. Another 30 percent of the hospital –acquired infections is acquired from exogeneous sources. This means that the infecting micro-organisms were transferred from external sources such as other patients, health-care workers (doctors or nurses), and from the innate environment (e.g. floors, showers, ceilings). In additon, diagnostic or therapeutic interventions may also cause infections in patients. One of the main route of transmission of microorganisms is through direct or indirect contact with healh care workers that do not properly apply handhygiene protocols.

Morbidity, mortality and costs

Excess length of stay (LOS) is a proxy for morbidity attributed to HAI. Surgical site infections add, on average, 11 days to a hospital stay. Central line-associated bloodstream infections 10 days. Central line–associated bloodstream infections are found to be the most costly HAIs at $45 814 (95% CI, $30 919-$65 245), followed by ventilator-associated pneumonia at $40 144 (95% CI, $36 286-$44 220), surgical site infections at $20 785 (95% CI, $18 902-$22 667), Clostridium difficile infection at $11 285 (95% CI, $9118-$13 574), and catheter-associated urinary tract infections at $896 (95% CI, $603-$1189). The total annual costs for the 5 major infections were $9.8 billion (95% CI, $8.3-$11.5 billion) in the United States of America, with surgical site infections contributing the most to overall costs (33.7% of the total), followed by ventilator-associated pneumonia (31.6%), central line–associated bloodstream infections (18.9%), C. difficile infections (15.4%), and catheter-associated urinary tract infections (<1%)[5].

1.2 PREVENTION

As many as 65% of CABSI and CAUTI and 55% of VAPs and SSI may be preventable with current evidence-based strategies[6]. In the Netherlands the national Quality and Safety programm (VMS) regards HAI as one of the important safety issues and focuses on the prevention of SSI's and CABSI. Handhygiene and personal hygiene of care-givers are taken to be the cornerstone of each hospital's infection prevention policy.

1.3 SURVEILLANCE

Surveillance of HAI is the systematic collection of data; consolidation and analysis of these data into useful information and dissemination of results to persons who need to know and can take action[7]. Surveillance is thought to be a conerstone of strategies aimed to contain and reduce the occurrence of HAI, it should yield serial data about the occurrence – incidence or prevalence rates - of all types of HAI across a particular health care setting such that fully informed evidence-based decisions can be made to prioritise and structurally address the relevant infection issues of the health care setting.

Point Prevalence Surveys of hospital-acquired infections in the Netherlands and Europe

From repeated point-prevalence surveys (PPS) performed in the framework of the national Dutch surveillance program we have learned that there is a significant decrease in the point-prevalence of HAI in Dutch hospitals in March and October of the years 2007-2013 from 8 % to 3,6 % (see figure 1)[8]. However, from 2014 to 2017 the number of participating hospitals and patients included in these PPS decreased, from 43 to 20 and from 17.989 to 12.591 respectively (see figure 2).

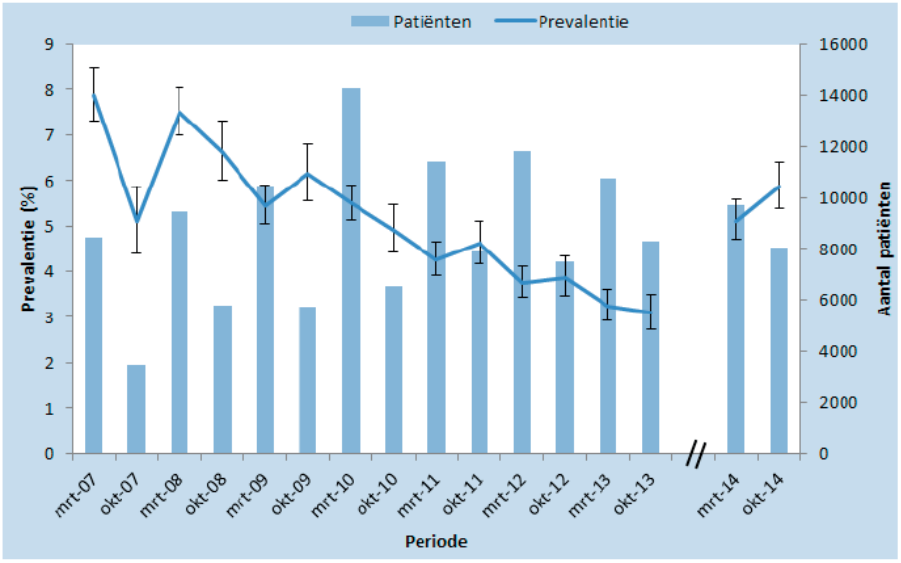

Figure 1. Trend in point-prevalence of Hospital Acquired Infections (HAI) in Dutch hospitals, defined as the total number of HAIs detected divided by the total of patients admitted on the prevalence date. From 2014 onwards point-prevalence includes patients that were (re)admitted with a HAI present, hence the higher prevalence rates observed since 2014.

In 2011-2012 the European Centre for Disease Prevention an Control (ECDC) coordinated a pan-European point-prevalence survey (PPS) for HAI. From these data it was estimated that on any given day, 5.7% of patients admitted to European hospitals have at least one HAI (95% confidence interval: 4.5–7.4%). The second pan-European PPS in 2016-2017 showed that the HAI prevalence had not changed over time (5,5%). 1,209 of the 8,307 (14,6%) acute hospitals available in Europe participated in this PPS.

The low percentage of hospitals participating in the pan-European PPS and the decrease in hospitals participating in the PREZIES Dutch national PPS implies that

for the majority acute care hospitals, hospital-wide point prevalence rates of HAI are not readily available nor are these surveys routinely or easily performed, and that the information coming from these yearly PPS are not deemed indispensable for infection control. Surveillance routinely performed by infection control personnel has typically been rather labour intensive which, in the face of the limited resources available in most health care settings has driven most health care centres to stop hospital-wide surveillance for all types of HAI and only apply so called targeted forms of surveillance that include only few, high risk wards and/or few types of medical procedures and/or only a few types of HAI.

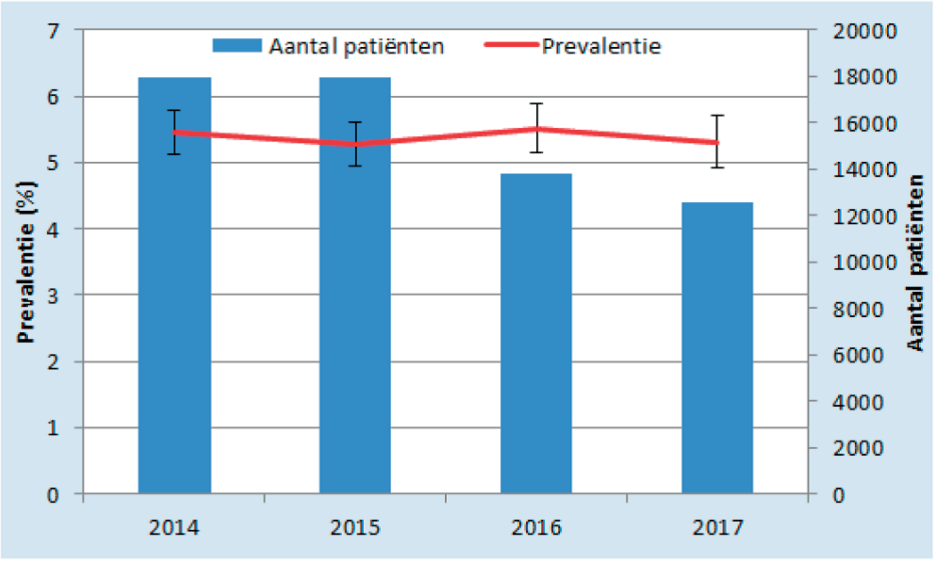

Figure 2. Hospital Acquired Infection prevalence and number of patients included in PREZIES national point prevalence surveys 2014-2017.

1.4 AIM AND OUTLINE OF THIS THESIS

The general aim of this thesis is to contribute to the implementation of surveillance of hospital acquired infections in health care settings, especially acute care hospitals, by significantly reducing the time spent on surveillance and by simultaneously increasing its scope and accuracy. These goals were addressed by designing, developing, and implementing an electronically assisted surveillance system (EASS) of HAI, which is based on high-frequency, hospital-wide, computer-assisted point prevalence surveys (CAPPS).

In part I Design and development of computer-assisted point-prevalence surveys, chapter 2, we present a systematic review of the performance and characteristics of EASS published from 1980-2018. In chapter 3, the algorithm's development and how a computer-assisted point prevalence survey is performed are outlined. In Part II Validation, chapters 4 and 5, three studies are presented that support the idea that hospital-wide point-prevalence surveys for HAI can be performed more efficiently and with high sensitivity in different hospital settings by using CAPPS. Validation of the CAPPS was performed by comparing the results of the CAPPS with the results of the traditional PPS, as executed by the Dutch national surveillance system. In Part III Implementation of computer-assisted point-prevalence surveys, chapter 6, we present how data gathered by frequently repeated hospital-wide CAPPS can be consolidated and analyzed into information regarding trends of different types of HAI at the level of a whole hospital and at the level of individual hospital departments. In chapter 7, we present a different, but valuable application of the EASS datamart and software, namely to facilitate a PPS and audit of antimicrobial use in an hospital setting. Finally, in chapters 8 and 9 a summarizing discussion, future perspectives and a Dutch summary are presented.