Evaluation of the surveillance of surgical site infections within the Dutch PREZIES network

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Introduction

INTRODUCTION

Healthcare-associated infections continue to represent a significant public health problem. Even though some infections are unavoidable due to the inherent risks of underlying disease and medical interventions, infection rates can and should be decreased.
In the Netherlands, about 3% of surgical patients develop a surgical site infection (SSI), which leads to a longer duration of hospitalization, an increase in morbidity and mortality rates, and an increase in costs.[1-3] SSI rates, especially in clean surgery in which no bacteria-colonized tract of the body is opened, are considered an indicator of the quality of surgical and postoperative care in hospitals.
Surveillance is the ongoing systematic collection, analysis, interpretation, and feedback of data, followed if necessary by implementation of interventions. It is characterized by the Plan-Do-Study-Act cycle, developed by the American Institute for Healthcare Improvement.[4] Surveillance has been widely accepted throughout the world as a primary step toward prevention of healthcare-associated infections. In order to be successful and to generate accurate and reliable data, the surveillance system should comply with several criteria.
In the Netherlands, a national network for the surveillance of nosocomial infections was set up in 1996. The first module concerned SSIs, and so far 90% of all acute care hospitals in the Netherlands have participated for a period between 3 months and 11 years.
The underlying question of this thesis is to assess the quality of the Dutch SSI surveillance and whether it could be optimized. Therefore, the methods and applications of the surveillance were critically evaluated and the trend in SSI incidence studied.

Background of surgical site infections

Healthcare-associated infections are infections that develop as a result of the patient's stay in a healthcare facility like a hospital, nursing home or rehabilitation centre. 'Nosocomial infections' is a subgroup, which encompasses infections related to procedures, treatments, or other events that occur during hospitalization. Such infections reveal not necessarily during hospitalization; often they manifest later. The incidence of nosocomial infections can reflect the quality of care in the hospital.

Modern surgery can be said to have its roots in the 19th century with the development of asepsis and narcosis.[5] As a result, reconstructive, tissue-preserving operations began to replace amputations.[6] After a surgical procedure, the patient may develop a SSI. The development of a SSI can be multicausal, but the necessary cause is damage to host barrier mechanisms induced by the trauma of a surgical incision. For most SSIs, the source of pathogens is the endogenous flora of the patient's skin, mucous membranes, or hollow viscera.[7 8] However, contamination may also occur from an exogenous source such as surgical personnel, the operating environment, and all tools, instruments, and materials brought to the sterile field during an operation. Excellent surgical technique is widely believed to reduce the risk of SSI. Such technique includes maintaining effective hemostasis while

preserving adequate blood supply, preventing hypothermia, gently handling tissues, avoiding unintentional entries into a hollow internal organ, removing devitalized (e.g., necrotic) tissues, using drains and suture material appropriately, eradicating dead space, and appropriately taking care of the postoperative incision.[3] The surgical technique has improved over the last decades, and more often minimally invasive (laparoscopic or endoscopic) surgical procedures are performed, which causes fewer SSI.[9 10]

SSIs are divided into (Figure 1):

- superficial incisional SSIs: involving only skin or subcutaneous tissue of the incision,
- deep incisional SSIs: involving deep soft tissues (fascial and muscle layers) of the incision;
- organ/space SSIs: involving any part of the anatomy other than the incision (e.g. organs or spaces), opened or manipulated during the operative procedure).

The surgical site is the second or third most-common site of all nosocomial infections, with infections of the urinary tract being the most-common. Among surgical patients, SSIs account for 38% of all nosocomial infections. Currently, about 3% of surgical patients in Dutch hospitals develop a SSI.[11] SSIs have adverse consequences like a longer duration of hospitalization of on average a week, an increase in morbidity and mortality rates, and an increase in antibiotic use. Consequently, SSIs lead to an increase in healthcare costs, varying from €1,000 per superficial SSI to €20,000 per severe deep SSI. These costs refer to direct hospital costs, e.g., extra bed days, diagnostics, medication and revision surgery.[12 13]

Determinants for the development of SSI

Knowledge of patient and operation characteristics that may influence the risk of SSI development (directly or indirectly) is useful in two ways. First, they allow stratification of operations, making

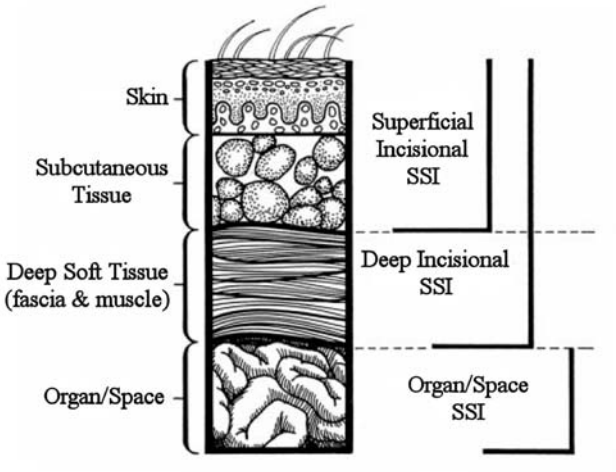

Figure 1. The anatomy of surgical site infections and their appropriate classification.[62]

surveillance data more comprehensible. Second, knowledge of risk factors beforehand, may allow for targeted prevention measures.

Four key factors, which interact in a complex way, affect the risk of surgical site infection:

- the degree of bacterial contamination;
- the virulence of the microorganism;
- the resistance of the host, i.e., the patient's ability to control the microbial contamination;
- the physiologic condition of the surgical site at the end of the operation. A surgical site that is poorly vascularized or that contains damaged or necrotic tissue or foreign material is at higher risk of infection given the same degree of microbial contamination. The condition of the surgical site is also determined by the underlying disease process that necessitated surgery (e.g., the severity of trauma) and by operative technique (i.e., the skill of the surgeon).

Studies have identified other risk factors, but they may be viewed as secondary in that they are likely to act through interaction with the key factors; e.g., by affecting the resistance of the host or the condition of the surgical site. Age as a risk factor is linked to co-morbidities like thinning of the dermis which is more susceptible to ischemia, diminished host immune responses, increased exposure to long-term care facilities, and malnutrition.[14] Smoking delays the primary wound healing secondary to decreased oxygen tension in the tissue. Obesity is associated with a poor tissue oxygenation in adipose tissue and a higher incidence of diabetes.[15] Diabetes itself is associated with hyperglycemia, in case of unsatisfactory glucose control. Hyperglycemia during the immediate postoperative period is an independent risk factor for development of SSI, because of a direct effect of elevated glucose on immune mechanisms.[16]

As mentioned above, the risk of developing an SSI is influenced by the degree of microbial

Table 1. Surgical wound classification.[3]

Class	Surgical wound contamination
1 Clean	An uninfected operative wound in which no inflammation is encountered and the respiratory, alimentary, genital, or uninfected urinary tract is not entered. In addition, clean wounds are primarily closed and, if necessary, drained with closed drainage. Operative incisional wounds that follow nonpenetrating (blunt) trauma should be included in this category if they meet the criteria.
2 Clean-contaminated	An operative wound in which the respiratory, alimentary, genital, or urinary tracts are entered under controlled conditions and without unusual contamination. Specifically, operations involving the biliary tract, appendix, vagina, and oropharynx are included in this category, provided no evidence of infection or major break in technique is encountered.
3 Contaminated	Open, fresh, accidental wounds. In addition, operations with major breaks in sterile technique (e.g., open cardiac massage) or gross spillage from the gastrointestinal tract, and incisions in which acute, nonpurulent inflammation is encountered are included in this category.
4 Dirty/infected	Old traumatic wounds with retained devitalized tissue and those that involve existing clinical infection or perforated viscera. This definition suggests that the organisms causing postoperative infection were present in the operative field before the operation.

contamination of the operative site. A widely accepted system of classifying operative site contamination was developed by the National Research Council in 1964 and modified in 1982 by the American Centers for Disease Control (CDC) for use in SSI surveillance (Table 1).[3] The incidence of infection increases as the wound classification changes from clean to dirty.

Table 2. Physical status classification, American Society of Anesthesiologists.[17]

ASA Class	Patient's preoperative physical status
1	Normally healthy patient
2	Patient with mild systemic disease
3	Patient with severe systemic disease that is not incapacitating
4	Patient with an incapacitating systemic disease that is a constant threat to life
5	Moribund patient who is not expected to survive for 24 hours with or without operation

The American Society of Anesthesiologists (ASA) physical status classification is widely used as a measure for intrinsic host susceptibility, with a higher score indicating an increased infection risk (Table 2).[17] An advantage of the ASA classification is that it is already available before the start of surgery. A drawback is that it represents a subjective parameter, which might result in inter-physician variations.[18 19]

The length of operation has long been established as an important risk factor for SSIs.[20] In the 1980s, surgery lasting more than 2 hours was found to be an important risk factor for SSIs.[21] Later, the 75th percentile of the distributions of duration of surgery for each procedure seemed to be a better predictor of infection.[22] Exactly how prolonged surgery increases the risk for SSI remains speculative, but it might be influenced by the experience of a surgeon, the complexity of the surgery, or by complications during surgery.[23]

In 1991, the NNIS risk index was developed in America, which combines three risk factors.[22] One point is scored for each of the following when present:
1) American Society of Anesthesiologists (ASA) physical status classification of >2;
2) Either contaminated or dirty/infected wound classification;
3) Length of operation > 75th percentile of the specific operation.
For calculation of the NNIS risk index, PREZIES uses the 75th percentile of duration of surgery in minutes per surgical procedure, which is computed from the PREZIES data.

Infection control

In the Netherlands in 1980, the Working Party on Infection Prevention (WIP) was founded to stimulate infection prevention in the Netherlands. Professionals from three Dutch societies are participating in the WIP: the Infectious Disease Society of the Netherlands, the Dutch Society of Medical Microbiology, and the Society for Hygiene and Infection Prevention in Healthcare. The WIP develops and publishes up-to-date, scientifically based guidelines for prevention of healthcare-associated infections. The guidelines are meant to be a helping hand in the preparation

of local guidelines. Regarding SSIs, a relevant guideline is 'Prevention of postoperative wound infections', which includes recommendations regarding:

- preoperative factors: preparation of the patient, hand/forearm antisepsis for surgical team members, management of infected or colonized surgical personnel, administration of antimicrobial prophylaxis;
- intraoperative factors: ventilation of the operating room, cleaning and disinfection of environmental surfaces, microbiologic sampling, sterilization of surgical instruments, using surgical attire and drapes, surgical technique;
- postoperative factor: incision care.

Surveillance of SSI

The first large nosocomial infection surveillance network was set up in America by the CDC in 1970, known as the National Nosocomial Infections Surveillance (NNIS) system.[24] Currently, many countries worldwide have a nosocomial infection surveillance system with methods and infection definitions adopted from the American NNIS system. Nowadays, surveillance has been generally accepted as a primary step toward prevention of nosocomial infections and thereby improvement of patient safety.[25]

The American Institute for Healthcare Improvement developed a tool for testing changes in healthcare.[4] The *Plan – Do – Study - Act* cycle is shorthand for testing a change by developing a plan to test the change (Plan), carrying out the test (Do), observing and learning from the consequences (Study), and determining what modifications should be made to the test (Act) (Figure 2). This tool can also be used for surveillance of nosocomial infections.

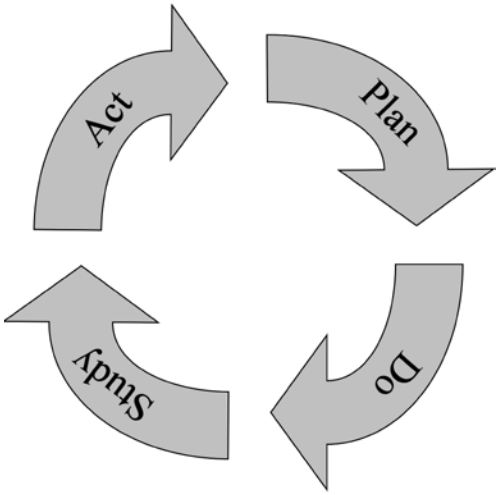

Figure 2. The *Plan – Do – Study - Act* cycle.

For SSI surveillance within a national network, the steps might include the following aspects:

- Plan: determine the included surgical procedures, the registration period, the goal regarding the SSI incidence (e.g., below the national 25th percentile), and the data needed to be collected by whom.
- Do: carry out the surveillance according to the protocol and send the data to the national nosocomial infection surveillance network.
- Study: use the received feedback report to compare the data with your predictions, and summarize and reflect what you learned. Feed back the results to involved personnel.
- Act: determine what modifications should be made and prepare a new plan.

Critical components for a high-quality and successful nosocomial infection surveillance system, both on national and on hospital level, are[26-30]:

- Voluntary and confidential participation.
- A written plan with goals and objectives.
- Efficient use of limited resources.
- Standardized surveillance protocols and methods: using the same exact, concise, and nonambiguous definitions and apply them consistently is essential for accurate infection rates and reliable inter-hospital comparison.
- Risk-adjustment of infection rates: control for variation in case mix, underlying disease and severity of illness at participating hospitals.
- Feed back of surveillance results: feed back of risk-adjusted and reliable infection rates to the involved healthcare professionals may substantially affect their behavior and enable them to take appropriate action, and may be the catalyst for organizational improvements.

Promoting factors are:

- Close collaboration among all healthcare workers within the hospitals.
- Close collaboration and dedication of infection control professionals and of the network team.
- Infection control professionals should be trained professionals that understand epidemiology and surveillance.
- Computer support, information and technology services, and administrative support.
- Regular evaluation of the surveillance.

In summary, surveillance is the ongoing systematic collection, analysis, interpretation, and feedback of data. After determination of baseline rates of nosocomial infections, changes in the rates can be detected, e.g., to determine whether interventions were effective.

The structure of this thesis follows the steps of the *Plan – Do – Study - Act* cycle, with the methods of the Dutch PREZIES network described in the 'Plan-step'. In the 'Do-step', aspects regarding the execution of surveillance are evaluated, namely validation and postdischarge surveillance. Risk-adjustment, comparison of the Dutch and the German surveillance data, and the change in SSI rate over time are discussed in the 'Study-step'. The 'Act-step' is used to describe the effect of implementing the national guideline for antibiotic prophylaxis on the SSI rate.

PLAN

Methods of the Dutch PREZIES network

In 1996, the national nosocomial surveillance network PREZIES ('PREventie van ZIEkenhuisinfecties door Surveillance') was set up in the Netherlands. It is a cooperation between the National Institute for Public Health and the Environment (RIVM), the Dutch Institute for Healthcare Improvement (CBO) and the participating Dutch hospitals. General goals of the PREZIES network are:

- Implement and maintain standardized surveillance of nosocomial infections to gain insight into the national (change in) incidence of nosocomial infections, risk factors and pathogens causing the infections. Furthermore, the surveillance data can support national policies.
- Generate comparable and accurate infection data so that hospitals can compare their infection rates with the national data, which may support optimization of the infection prevention policies in the hospitals.
- Create a basic infrastructure for intervention studies, which may support improvement in the quality of care and patient safety.

In 1996, the PREZIES network started with an incidence module on SSIs.[2] Other modules were developed later: incidence modules on SSIs after cardiac surgery, ventilator-associated pneumonia, and central venous catheter-related sepsis, and a prevalence module on all nosocomial infections. Participation in PREZIES is voluntary and confidential, and currently 90% of the 98 hospitals in the Netherlands participate. The person in the hospital responsible for the execution of the surveillance usually is the infection control professional. The participating hospitals should follow the protocols, and use the definitions of the PREZIES network for all variables and infections. The hospitals that participate in the SSI module, may choose the specific surgical procedures they want to include in the surveillance. Each healthcare organization must tailor its surveillance system to use limited resources optimally by taking into account population characteristics, outcome priorities, and organizational objectives.

The SSI definition of PREZIES is based on the one developed by the American Centers for Disease Control and Prevention, which was translated by the Dutch WIP. PREZIES made some specifications to this definition, i.e., that clinical symptoms must always be present and that the diagnosis of the surgeon or physician alone is not decisive. Acceptance of such a subjective diagnosis of a surgeon/physician, without any clarification or diagnostics, jeopardizes the comparability of the data. The diagnosis 'SSI' by the surgeon/physician will not be ignored, but a foundation of arguments needs to be inquired and should be reported. Furthermore, in PREZIES deep incisional SSIs and organ-space SSIs are evaluated under the umbrella term 'deep SSI', because in practice it is often difficult to distinguish deep SSIs from organ-space SSIs. Figure 3 shows a decision tree for assigning a SSI as published in a PREZIES brochure.

Participating hospitals collect data on putative determinants, based on international studies: age (date of birth), sex, type of surgical procedure, wound contamination class, ASA classification, duration of surgery, elective or acute procedure, administration of antimicrobial prophylaxis

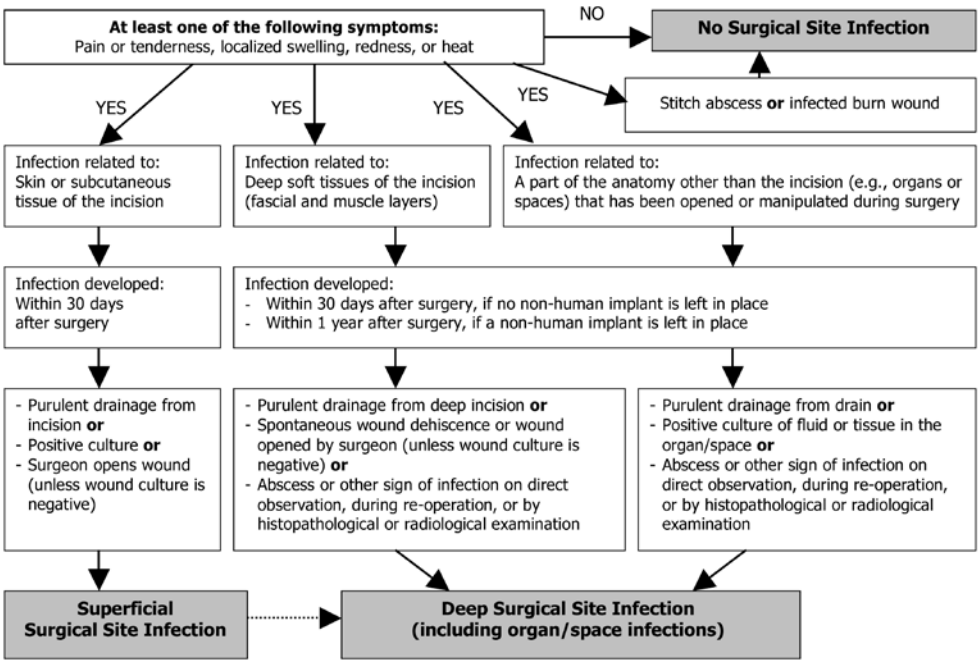

Figure 3. Decision tree for assigning the diagnosis of a surgical site infection (Source: PREZIES brochure).

(yes/no), multiple procedures performed through same incision, whether a non-human implant was left in place, and duration of hospitalization (date of admission, date of surgery, date of discharge). In case of an SSI, the date and type of infection are registered. The recording of cultured microorganisms is optional. Other optional variables that can be registered are obesity, method of pre-operative hair removal, and whether a re-operation occurred at the same body side.
For each surveillance module, workshops are organized yearly by PREZIES to give information, discuss positive and negative experiences, talk about possible infection prevention strategies, and practice cases studies.

DO

Postdischarge surveillance and validation
Important aspects of SSI surveillance within the PREZIES network are the performance of postdischarge surveillance and the ongoing validation of the surveillance.
According to the CDC definition, a SSI can develop until 30 days or 1 year (in case of a non-human implant) after surgery. Because the duration of hospitalization of surgical patients is generally shorter than 30 days, SSIs may develop after hospital discharge. The follow-up of patients after discharge ('postdischarge surveillance') will result in more-accurate SSI rates.
In 1998, PREZIES developed a method for postdischarge surveillance (PDS)[31]. PDS is voluntary, and for each hospital is recorded if and how PDS is carried out. However, the number of SSIs found

after discharge if hospitals performed PDS according to this method has not been investigated yet. In ***Chapter 2*** of this thesis, the method for PDS that is recommended by PREZIES is described. Furthermore, the value of postdischarge surveillance is evaluated by showing the number of SSIs that developed after discharge. This might give an indication of the surgical procedures with the most SSIs recorded after hospital discharge, and thus with a high need for PDS.

To ensure the accurateness and reliability of the infection rates, the data and process of surveillance should undergo periodic evaluation and validation. In PREZIES, voluntary on-site validation was implemented in 1999, and validation has been mandatory for each participating hospital every three years since 2002. As validation is very time-consuming, it is important to evaluate its usefulness. Therefore, the method and value of the validation visits are studied in ***Chapter 3*** of this thesis.

Procedure: femoropopliteal or femorotibial bypass (CTG code 33675 + 33676)
Number of hospitals: 37
Registration period: January 1, 2004 – December 31, 2005

	Procedures No.	**Superficial SSI % (No.)**	**Deep SSI % (No.)**	**Total SSI rate % (95% CI)**	**Expected* total SSI rate % (95% CI)**	**Procedures with antimicrobial prophylaxis %**
Your hospital this period	106	5.7 (6)	3.8 (4)	9.4 (5.2-16.5)	5.2 (2.3-11.2)	93
Your hospital since 1996, standard method PDS	388	5.4 (21)	4.6 (18)	10.1 (7.4-13.4)	5.1 (3.3-7.8)	90
National since 1996, standard method PDS	2280	2.9 (65)	2.2 (50)	5.0 (4.2-6.0)	5.0 (4.2-6.0)	80
Your hospital since 1996, no (standard method) PDS	-	-	-	-	-	-
National since 1996, no (standard method) PDS	1346	1.8 (24)	1.6 (21)	3.3 (2.5-4.4)	3.3 (2.5-4.4)	83

PDS: postdischarge surveillance
* Expected SSI rate is adjusted for NNIS risk index

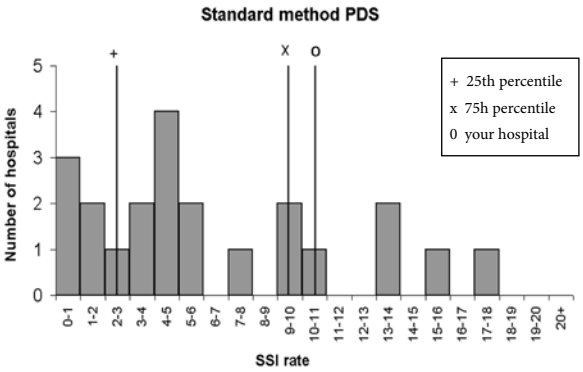

Figure 4. Example of a feedback report from PREZIES to the participating hospitals.

STUDY

Risk adjustment of SSI surveillance results in feedback reports

Every time a hospital sends data to the PREZIES network, it receives a procedure-specific feedback report, with its infection rates compared with the national rates. An example of a feedback report for the SSI module is shown in Figure 4.

For comparison of SSI rates between hospitals or within a hospital over time, it is important to correct for risk factors related to the patient, surgery or hospital. Nowadays, the NNIS risk index is used for risk-adjustment of SSI surveillance data by many countries. However, recent studies have shown that the NNIS index might not be the optimal risk score for all surgical procedures.[18 32 33]
In PREZIES, hospitals can compare their observed SSI rate with a predicted SSI rate, which is calculated by using the NNIS index. In ***Chapter 4*** of this thesis, we evaluate the accurateness of the predicted SSI rates and assess whether the risk adjustment can be improved. For many surgical procedures, we compare the predictive power of the NNIS index to new models including other determinants.

Comparison of SSI surveillance between the Netherlands and Germany

There is an increasing interest in comparing SSI data, not only between hospitals within a country, but also between countries. We as well wondered how patient safety in the Netherlands is related to other countries. However, comparing countries is more difficult than hospitals within a country, because the healthcare system and practices, type of hospitals, patient-mix, and reason for participation in a national surveillance system are likely to vary between countries. A previous study showed that the practice of the surveillance in the Netherlands (PREZIES) and Germany (KISS) are comparable: their protocols are based on the American NNIS protocol using the definitions developed by the CDC, participation is voluntary and confidential, the project is funded by the Ministry of Health, and the networks are coordinated centrally by a multidisciplinary team.[34]
Therefore, in ***Chapter 5*** of this thesis the SSI surveillance data of KISS and PREZIES are compared regarding the patient and hospital characteristics and SSI rates for several surgical procedures

The time-trend in SSI rate

Already in 1985, Haley showed that SSI control programs could reduce hospitals' infection rates by 32% if the programs included organized surveillance and control activities, a trained infection control physician, one infection control nurse per 250 beds, and a system for reporting infection rates to practicing surgeons.[21] Since then, the effect of surveillance in reducing SSI rates has been demonstrated by others.[35-38]
Also for the Dutch PREZIES surveillance data, a reduction in SSI rate with longer participation was shown by Geubbels.[39] She used SSI surveillance data from the period 1996-2000, and analyzed the trend in SSI rates over seven pooled procedures as to increase power. The number of records in the PREZIES database has more than doubled since. Therefore, in ***Chapter 6*** of this thesis, we

evaluate the time-trend in SSI rate in relation to the duration of surveillance, separately for five frequently-performed surgical procedures, using data from 1996 to 2006.

ACT

Interventions that change infection control in the hospital can lead to improvements in the quality of care and with that may reduce the number of nosocomial infections. A national network for surveillance of nosocomial infections can serve as an infrastructure for intervention studies on the quality of care. The PREZIES surveillance network contributed to a multi-center intervention project to improve the quality of surgical prophylaxis. PREZIES provided the 'patient outcome' parameter, namely the occurrence of SSIs.
The goal of prophylactic antibiotics is to eradicate or inhibit the growth of contaminating microorganisms such that SSIs can be avoided. An adequate concentration of antibiotic within the serum and tissues during the period between incision and closure of the wound is necessary. The efficacy of antimicrobial prophylaxis for preventing SSIs was established in the 1960s and has since been demonstrated repeatedly.[40-43] Proper administration of antimicrobial prophylaxis might prevent 40% to 60% of SSIs.[3] The timing of the first administration is critically important and the most common problem in antibiotic prophylaxis for SSIs.[41 43 44] Consensus guidelines state that prophylactic antibiotics should be given within 60 minutes before incision to achieve therapeutic levels,[3 45 46] and both early and late administration increase SSI rates.[43]

In 2000, the Dutch Working Party on Antibiotic Policy (SWAB) developed a guideline for perioperative prophylaxis in Dutch hospitals.[47] This guideline focuses on procedures that are performed relatively often, those with a relatively high SSI risk, those for which the consequences of a SSI would be severe and those for which the benefit of prophylaxis has been studied extensively. The guideline recommends intravenous prophylaxis of an inexpensive non-toxic antibiotic with a limited spectrum, which is not used extensively in therapy, administered within 30 minutes before the first incision. For reasons of cost-effectiveness and prevention of induction of resistance, single-dose prophylaxis is recommended, which has been proven as effective as multiple-dose prophylaxis for most procedures[48-53].

In 2000-2002, the Surgical Prophylaxis and Surveillance project (CHIPS) took place, in which the adherence to local hospital guidelines for surgical prophylaxis was assessed, and the national guideline issued by the SWAB was implemented. The aim of the CHIPS project was to improve the quality of prophylaxis in Dutch hospitals and to promote prudent use while maintaining or improving the efficacy of prophylaxis in reducing SSIs. This prospective multi-center intervention study had a before-and-after design without a control group. Thirteen hospitals throughout the Netherlands participated, which is 13% of all hospitals in the Netherlands. All hospitals participated in the component "Surgical site infections" of the Dutch PREZIES network. The CHIPS study was limited to frequently performed procedures for which antimicrobial prophylaxis is generally

recommended[47 54]: grafting of the aorta, femoropopliteal or femorotibial bypass, various colorectal procedures, abdominal and vaginal hysterectomy with or without vaginal repair, total hip arthroplasty and replacement of the head of the femur.

During the pre-intervention period, the antibiotic choice, duration, dose, dosing interval and timing of the first dose were concordant with the hospital guideline in 92%, 82%, 89%, 43% and 50%, respectively. Adherence to all aspects of the guideline simultaneously, however, was achieved in only 28%.[55] After the pre-intervention period, every hospital received feedback of its own results on the administration of antibiotic prophylaxis. Depending on the results, the intervention focused on modification of local guidelines, guideline adherence or both.

Prophylaxis was completely administered according to the recommendations of the national guideline in only 0.4% of the patients before the intervention, and in 25% after the intervention. After the intervention, the antimicrobial use decreased from 121 to 79 defined daily doses per 100 procedures, costs were reduced by 25% per procedure, and antibiotic choice and duration improved.[56] However, the reduction in antibiotic use was not supposed to lead to a decreased efficacy of prophylaxis, as measured by a higher SSI incidence. Therefore, in ***Chapter 7*** of this thesis the patient outcome of the optimized and restrictive antimicrobial prophylaxis policy is assessed by comparing the SSI rate before and after the intervention.

SSIs after total hip arthroplasty are rare but severe, often leading to revision surgery and impairment of short-term functional outcome, and resulting in a slight increase in mortality risk.[57] It is the most-often registered type of surgical procedure within PREZIES. Most studies that have analyzed risk factors for SSIs following total hip arthroplasty have mainly focused on patient, procedure, or hospital characteristics.[58-61] However, prospective studies of the contribution of the qualitative aspects of surgical prophylaxis to the prevention of SSIs following this procedure are scarce. In ***Chapter 8***, the contribution of prophylaxis process parameters to the incidence of SSI for the population undergoing total hip arthroplasty is explored, with emphasis on the timing of administration of prophylaxis.

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