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

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General discussion

Surveillance has been accepted worldwide as a primary step toward prevention of healthcare-associated infections. In order to generate accurate and reliable data and to be successful in reducing infections, a surveillance system should comply with several criteria. In the Netherlands, a national network for the surveillance of nosocomial infections was set up in 1996 and called PREZIES ('PREventie van ZIEkenhuisinfecties door Surveillance'). It started with the surveillance of surgical site infections (SSIs), and so far 90% of all acute care hospitals in the Netherlands have participated for a period between 3 months and 11 years.
In this thesis, the quality of the SSI surveillance within the Dutch PREZIES network is evaluated. Therefore, the methods and applications of the surveillance were critically evaluated and the trend in SSI incidence studied. Our study proved that the method for postdischarge surveillance recommended by PREZIES is feasible and effective and that the mandatory validation visits ensure the reliability and robustness of the surveillance data. Furthermore, the predictive power of the NNIS risk index was sufficient for several surgical procedures and could not be significantly improved by using other procedure-specific determinants. Analysis of the time-trend in SSI rates for 5 surgical procedures showed encouraging decreasing trends, although mostly not statistically significant. Comparison of the Dutch and German SSI surveillance data revealed that even though similar infection surveillance protocols were used, differences occurred in the implementation which hampered the comparison of SSI rates. Additionally, PREZIES contributed to a multi-center intervention project to improve the quality of surgical prophylaxis. The implementation of an optimized and more-prudent antibiotic policy in hospitals did not change the effectiveness of the antibiotic prophylaxis concerning SSI prevention. Detailed analysis of the effect of various prophylaxis parameters following total hip arthroplasty showed that the timing of administration of the first dose (and not the duration) was the most important prophylaxis-related factor for the risk of SSI.

The structure of this thesis is characterized by the *Plan – Do – Study – Act* cycle, developed by the American Institute for Healthcare Improvement for evaluating the effect of changes in e.g., infection prevention activities.[1]

PLAN – Develop a surveillance plan with included surgical procedures, period, tasks of involved personnel, and objectives.

Within PREZIES, hospitals have always been allowed to choose any surgical procedure for inclusion in the surveillance. Sometimes, this led to the surveillance of rarely performed procedures, which resulted in low reliability of the SSI rates (i.e., wide confidence intervals). Furthermore, national reference rates were often lacking for these procedures because reference rates are only generated for procedures with at least 100 records (for reliability) that are registered in at least three hospitals (for confidentiality). Therefore, we feel that limiting the SSI surveillance of PREZIES to regularly performed procedures and to procedures where SSIs have severe consequences (e.g., replacement of hip prosthesis as a result of an SSI) will result in more-efficient use of limited resources and

in more-precise SSI rates. The German KISS network, for example, already focuses their SSI surveillance on 25 so-called 'indicator procedures'.[2] Because a hospital should be able to get insight into the overall SSI problem, the 'indicator procedures' should be carefully chosen and all surgical specialties should be represented.

Because hospitals can determine the surveillance period for each surgical procedure, some hospitals have followed the same procedure for over 10 years. To enlarge the effectiveness of surveillance and use limited recourses as efficient as possible, we would suggest switching the surveillance to another procedure when the SSI rate has decreased below the target. This indicates once again the significance of specifying aims before starting the surveillance.

The value of the PREZIES nosocomial surveillance network has been recognized by the Dutch authorities. The Dutch Healthcare Inspectorate (IGZ) has included SSI surveillance as a hospital-wide structure indicator in the basic set of Hospital Performance Indicators since 2004. The Healthcare Inspectorate is of opinion that active surveillance should be part of the infection prevention policy and recommends that hospitals should participate at least once a year in one of the modules of PREZIES. Since then, the number of PREZIES participants further increased, probably because the hospitals fell obliged to participate. In the hospitals, the responsible person for the surveillance is usually the infection control professional (ICP). However, currently in rarely any Dutch hospital the desired standard of 1 full-time equivalent ICP per 5000 admissions is reached.[3] Besides, this standard does not say anything about how much time an ICP can or may truly spend on surveillance. We would recommend that hospitals appoint as many ICPs as needed according to the standard, with enough time available for the execution of surveillance. The availability of electronic data is increasing and will make surveillance less time-consuming.

DO – Execute the surveillance.

The results and universal applicability of the Dutch validation method

Validating surveillance data is of the utmost importance for ensuring the accuracy of the data. PREZIES uses a validation method in which the execution of the surveillance in each participating hospital is validated at least once every three years. During the validation visits, the method of data collection according to the protocol (by means of a structured interview) and the application of definitions (by reviewing medical records) are assessed. In *Chapter 3* we described the validation method in detail and the validation results showed that this method appeared to be feasible and valuable. The positive results of the validation visits indicate that the sensitivity of case-finding was high and that the criteria for assessing a SSI were applied correctly, which ensures the reliability of the surveillance data accumulated in the PREZIES database.

An international 'gold standard' for performing validation of surveillance data has not yet been defined. Many validation studies have been reported, with various methods revealing different sensitivity and specificity.[4-7] To our knowledge, no other national SSI surveillance system executes

validation continuously. Combining the experience of all European validation studies performed might be helpful in order to develop a protocol for a meaningful and cost-effective method for performing validation studies, as Gastmeier suggested.[8]

The value of the validation method used by PREZIES seems high, but the method might not be feasible in larger countries, where the distance to hospitals is too far to perform one-day onsite visits and where the number of participating hospitals might be too large to validate them all every three years. A possible solution might be that ICPs perform the validation visits in nearby hospitals. To warrant the quality of the validation, ICPs should be trained to perform validation visits in other hospitals. Alternatively, validation visits might be restricted to a random sample of the participating hospitals, but then the reliability of all surveillance data can not be guaranteed.

Besides validation visits, another item of the PREZIES surveillance that contributes to the accuracy of the data and might be implemented in other SSI surveillance networks is elucidation of all items of the protocol, like emergency procedure, revision surgery, wound contamination class and ASA classification. These clarifications are published on the network's website as well as in some publications in a Dutch journal intended for ICPs. Furthermore, every two months a case study is published on the website of PREZIES, by which ICPs may practice the application of SSI definitions.

The value and difficulties of postdischarge surveillance

Another aspect of the PREZIES surveillance that contributes to the quality assurance of the national SSI data is postdischarge surveillance (PDS), i.e., the follow-up of patients after hospital discharge. PDS helps to avoid underreporting of SSIs and to obtain true infection rates. Besides, PDS diminishes or even eliminates the effect of changes over time or differences between hospitals in length of stay on SSI rates. Internationally, a gold standard for performing PDS has not yet been specified. In 1998, PREZIES developed a method for the performance of PDS, which is addition of a special registration card to the outpatient medical record, on which the surgeon notes clinical symptoms and whether a patient developed an SSI according to the definitions.[9] Examination of all outpatient medical records is the alternative method for PDS. These methods for PDS are recommended and assumed feasible and reliable, because in the Netherlands almost every patient is seen again by the surgeon after hospital discharge. For each hospital, the performed method for PDS is recorded. Therefore, surveillance results can be compared between hospitals that perform PDS according to the same method (recommended method, other active method, or no PDS). This increases the reliability of the comparison of infection rates. In *Chapter 2* we showed that the number of hospitals performing PDS increased yearly, with almost 70% of the participating hospitals performing PDS according to the recommended method in 2005. The recommended method for PDS seemed effective because 43% of all included SSIs were recorded after discharge, compared with 30% after discharge when another method for PDS was used, and 25% in case no (active) PDS was carried out. The highest percentage of postdischarge SSIs (i.e., postdischarge SSI as a percentage of all SSIs) identified by recommended PDS was found for appendectomy (76%), followed by knee prosthesis surgery (64%) and mastectomy (61%). Some studies detected more

SSIs after discharge,[10-12] however, the results are probably influenced by differences in the average length of hospitalization, which hinders reliable comparison.

Because most SSIs after discharge were detected by use of the recommended method for PDS, we modified the hospital-specific feedback report of PREZIES in 2006: observed and expected SSI rates were reported separately for recommended PDS and for other or no PDS, instead of overall observed and expected SSI rates. These changes increased the accuracy of the comparison of hospital-specific data with national reference numbers.
In many other national SSI surveillance systems, SSIs after discharge are not included and/or the performed method of PDS in the participating hospitals is rarely recorded, which makes the correctness of inter-hospital comparison in those countries questionable. For example, in Germany, postdischarge surveillance is strongly recommended but not mandatory, because systematic postdischarge surveillance is not yet feasible in Germany. SSIs after discharge are included, but it is not recorded which and how hospitals perform PDS.[13] In Australia, SSIs after discharge are not included in the national database, unless the patient was readmitted to the same hospital.[14] In Scotland, SSI surveillance is mandatory for National Health Service hospitals, but they publish only in-hospital rates of SSI.[15]
Because of a decreasing trend in patients' postoperative hospital stay *{see discussion of Chapter 6}*, more SSIs will develop after the patient has left the hospital, which makes PDS increasingly important. In order to obtain highly accurate SSI surveillance data, we think that the performance of PDS according to a high-quality method should be obliged. Therefore, we decided that all participating hospitals in PREZIES must perform PDS according to our recommended method from 2009 onwards. Because PDS is time-consuming and requires cooperation with surgeons, PDS might be difficult to organize and achieve in some hospitals. Thus, making PDS mandatory might reduce the number of participating hospitals. However, because almost 80% of the Dutch hospitals that participate in PREZIES currently performs PDS in one way or another, this reduction in number of participants is probably limited and will not outweigh the advantage of the increase in quality of the surveillance data.
The major difficulty of postdischarge surveillance is to reach a 100% follow up rate. In the Netherlands almost every patient returns to the hospital where the surgery has taken place for checkup. This is probably not the case in many other countries. In this view, it might be useful to consider the number of patients that were lost to follow-up.

STUDY – Analyze the surveillance results and give feedback to involved staff.

Risk adjustment: is there room for improvement?

For reliable comparison of SSI surveillance data between hospitals, adjustment of SSI rates for relevant risk factors that may vary between patients and hospitals is very important. The NNIS risk index was developed in the United States in 1991. Since, this risk index has been used for

risk adjustment by many countries, also by PREZIES. More recently, it has been questioned whether adjustment for the NNIS index is valuable for all surgical procedures.[16-20] In *Chapter 4* we compared the predictive value of the NNIS index with alternative determinants that are routinely collected in PREZIES for several surgical procedures. That study showed that for some surgical procedure groups, alternative models can predict SSI occurrence better than the commonly used NNIS index. However, the practical relevance of the findings was limited, as changes in expected SSI numbers were small and there was no substantial gain in simplicity of the alternative models, as measured by the number of variables included. Therefore, we decided not to replace the NNIS index with procedure-specific determinants when comparing hospital and national SSI occurrence in feedback reports to hospitals.

The study also showed that the predictive power of the models was generally rather low (as measured by the area under the receiver operating characteristic curve) which indicates that there is still room for improvement. Notwithstanding that the PREZIES SSI surveillance is quite comprehensive, some aspects that may influence the SSI risk are lacking. Currently, mainly non-modifiable risk factors are included in the PREZIES protocol, e.g., age, gender, wound contamination class, and ASA classification. This was chosen because the main goal of PREZIES is to compare SSI rates between hospitals accurately and reliably. Judgment of the necessity of infection prevention activities is left to the hospitals' discretion. The aim of PREZIES is not (in the first place) to measure effects of interventions regarding modifiable factors.

In the future, we should consider whether the practicability of the surveillance data can be extended by inclusion of more non-modifiable risk factors (e.g., diabetes, body mass index, smoking and revision surgery)[21 22] or process measures that are known to affect the SSI risk (e.g., timing of antimicrobial prophylaxis, glucose control, routine on the OR, body temperature and oxygenation during surgery)[23-28]. However, for the feasibility of the surveillance, the extra time-investment that accompanies the registration of additional data should be watched. Furthermore, some factors affect the SSI risk only following specific surgical procedures, and recording procedure-specific risk factors would make the surveillance more complicated.

The influence of surveillance in reducing SSI rates

The ultimate goal of PREZIES is to decrease the number of nosocomial infections. The value of feedback of surveillance results to healthcare providers has been demonstrated earlier.[29 30] Therefore, in *Chapter 6* we evaluated 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. This study showed a decreasing trend in SSI risk with increasing surveillance time for some surgical procedures. Even though most decreasing trends in SSI rate were not statistically significant, they are encouraging. We cannot assert that the detected association between duration of surveillance and SSI rate was a causal relation and we do not know what exactly caused the decrease in SSI risk. We speculate that the reduced SSI rate might have been a result of improvements in the quality of care in the hospitals over time, like improved compliance with infection prevention guidelines. We somewhat expected a significant decrease in infection incidence for all procedures included in the

study. Possible reasons why the (indirect) effect of surveillance was limited are power deficiency and that feedback of the results did not reach all necessary staff or, more importantly, the results were spread but not comprehensively discussed with surgeons, operating room personnel, nurses, and the infection prevention committee. We think that the surveillance is more profitable if conclusions are drawn from the results (e.g., whether the SSI rate has decreased below the target) followed by actions to reduce the SSI risk or plans to switch the surveillance to other surgical procedures. Furthermore, whether feedback of surveillance results actually leads to a decrease in infection rates depends strongly on the motivation and discipline of all healthcare professionals to change their behavior and work according to protocols and guidelines.[31] Continuous education and repeatedly drawing attention to the risks linked to improper actions might contribute to this.
Another important factor that may influence the effectiveness of SSI surveillance is whether the ICP, who is usually responsible for the surveillance in a hospital, is able to form a partnership with the surgical staff. Creating a sense of ownership of the surveillance initiative amongst the surgical staff enhances co-operation and ensures that the best use is made of the information generated. Sharing information enables influencing behavior to reduce the incidence of SSI.[32] Communication and collaboration with anesthesiologist, the infection control committee and the management is also important, i.e., the execution of SSI surveillance should be multidisciplinary. From our experience we have observed that the degree and quality of collaboration between ICPs and surgical staff is suboptimal in some Dutch hospitals, which might interfere with improving infection control in the hospitals. The PREZIES surveillance network might help to optimize the collaboration by convincing the surgical staff of the value of surveillance, e.g., by organizing a meeting to inform them on the methods of the surveillance network (including the confidentiality of the data), on the workload of performing surveillance, and on how the surveillance results (on feedback reports) can be used for infection control.

Comparing SSI surveillance data between countries

We wondered how the Dutch procedure-specific SSI rates related to those of other countries. Registered SSI rates depend on the surveillance methods and on the healthcare system in a country. In *Chapter 5,* we decided to compare the SSI surveillance data from PREZIES with those from the German national nosocomial infection surveillance network (KISS), because they have comparable surveillance protocols and public healthcare systems.[33] Despite these conformities, differences occurred in the execution of the surveillance which made comparison of SSI rates less reliable than expected. We think that comparing SSI data between countries will be most reliable for deep SSIs during hospitalization, since these SSIs are not affected by postdischarge surveillance and the diagnostic sensitivity for deep SSIs is probably more similar between countries than for superficial SSIs.
As mentioned earlier, in KISS and many other surveillance networks, continuous validation of all participating hospitals does not take place and PDS is not mandatory and/or the performed method of PDS is not recorded per hospital. This is also the case for the NNIS network in the United States which serves as an example for many other surveillance systems. Thus, we think

that the value of comparing SSI surveillance results between countries is questionable and that countries should preferably focus on improvements within their country over time.

ACT – Specify essential proceedings and prepare a new plan.

Surveillance data regarding nosocomial infections give insight into problem areas which can encourage taking specific measures. The *Act*-step of the PDSA-cycle is an essential part for improving infection control and reducing the number of infections. It will mainly consist of performing interventions, improving compliance with current guidelines, or specifying and implementing new guidelines. However, this part was not the main goal of the PREZIES surveillance network when it was set up in 1996. The focus of PREZIES was to collect and publish infection data that could serve as a benchmark, with the hospitals themselves being responsible for starting prevention activities. Currently, the PREZIES-team occasionally gives advice to a hospital regarding interventions, discusses possible interventions during workshops, or brings a hospital in contact with a 'best practicing' hospital. It is outside the range of duties of PREZIES to actively monitor which infection control measures are performed by each hospital and what the results were of those actions. ICPs probably have the best view of what changes in infection control are needed in their hospitals and to what degree the healthcare activities deviate from the guidelines. However, changing behavior of healthcare workers is a complex and multi-faceted process affected by several factors, including knowledge, attitudes, expectations, and motivations.[31 34 35] We think that it might be helpful if PREZIES would organize specific workshops for ICPs to share their experiences in setting up and carrying out interventions, with discussion of perceived barriers and learned lessons.

Cooperation of PREZIES with other infection prevention activities

In the CHIPS study, PREZIES closely cooperated with an intervention study where the Dutch national guideline for antimicrobial prophylaxis was successfully implemented in 13 hospitals (*Chapter 7 and 8*). In this study, the PREZIES network provided a valuable framework for the set up of the study (hospitals were recruited mainly from the network), the data management and analyses (by epidemiologists of the PREZIES team) and the execution of the study (by ICPs, which kept staff expenses of the study low). A major strength of the CHIPS study was the multi-center approach of both measurement of the effect on process outcome (quantity and quality of surgical prophylaxis) and on patient outcome (SSI). The SSI surveillance data of PREZIES made it possible to show that the implementation of the more-prudent and restrictive antimicrobial policy had no detrimental effect on the efficacy of prophylaxis in preventing SSIs. Documentation of this patient outcome is very important for making restrictive measurements regarding prophylaxis acceptable for surgeons and for wider implementation (national and international). Furthermore, the CHIPS study provided scientific evidence that the timing of administration of the first dose of antibiotic prophylaxis (and not a longer duration of prophylaxis) was the most important prophylaxis-related factor for the risk of SSI after total hip arthroplasty.

However, a shortcoming of the design of the CHIPS study was that the CHIPS team was mainly in contact with ICPs and infection committees. Surgeons and anesthesiologists were limited involved, partly because surgeons were less accessible. This was detrimental, because surgeons are primarily responsible for the administration of surgical antibiotic prophylaxis.

More recently, two national initiatives were invented that cooperated with PREZIES, namely the 'Breakthrough' and 'Faster Better' projects. Between 2002 and 2004, 17 Dutch hospitals participated in two SSI 'Breakthrough' series, which were set up and coordinated by the Dutch Institute for Healthcare Improvement (CBO). Those hospitals tried to improve infection control by changing many process indicators that were derived from the literature and/or were successful in another hospital. One of the goals was to reach an SSI incidence below the 25th percentile at that time. Between 2004 and 2008, 24 Dutch hospitals participate in three 'Faster Better' tranches, in order to realize substantial quality improvements for patients and healthcare workers regarding safety and logistics. 'Faster Better' is a joint initiative of the Ministry of Health, the Dutch Hospital Association, the Order of Medical Specialists, and others. It consists of several sub-projects, one of which is the SSI Breakthrough project. Breakthrough series also use the *Plan – Do – Study – Act* cycle and the goal is a 50% reduction in SSI rate or an SSI rate below the national average. The hospitals that participated in one of these programs were encouraged to simultaneously participate in the SSI surveillance of PREZIES, which enabled linkage of the process and outcome measurements. The strength of Breakthrough programs is the multidisciplinary cooperation within the hospital, and the cooperation beyond the walls of a hospital. Support from colleagues is very important for the execution of surveillance as well as for the implementation or change of guidelines. In the Breakthrough series, key figures are appointed in each organization, who can help improvement-teams with financial and/or material barriers (e.g., the management) and/or with convincing specific disciplines to participate in interventions. The medical specialists are key figures for creating support and motivation for the SSI Breakthrough project within their own partnership.

Cooperation with and recognition by hospitals and experts becomes increasingly important and it might be of vital importance for PREZIES to seek further alliance with intervention programs. We think that more attention should be paid to embedding the surveillance in the total of infection prevention activities in the Netherlands. In that way, the surveillance results might be more extensively used for improvements in infection control with better guidance from experts, and thus might increase the effectiveness of the surveillance in reducing the number of nosocomial infections. Such initiatives are usually multi-center programs, which leads to more interaction between the hospitals. That enables hospitals to learn from each other about how processes and intervention measures can be organized optimally or how changes can be implemented more easily and effectively. These studies can vary widely regarding subject and design, like a cost-effectiveness study or a clinical study to investigate the value of a patient-related risk factor (e.g., glucose control) or a process factor (e.g., timing of antimicrobial prophylaxis).

Bundling best practices

Currently of interest is the new safety program 'Prevent injury, work safe in Dutch hospitals' (2008-2012), developed by the Ministry of Health, the Healthcare Inspectorate, the Dutch Hospitals Association, and others. The prevention of SSIs is the first of ten themes and the goal is to reach an SSI rate below the current 25th percentile per surgical procedure as measured in PREZIES in all hospitals. In the scope of the safety program, PREZIES has been asked to include a bundle of process measurements in the SSI module. A few years ago, the American Institute for Healthcare Improvement (IHI) introduced the term *bundle* into the field of infection control. However, the concept of bundles has been in use for many years, for example in the field of antibiotic policy (e.g., type of drug + dosage + timing + duration). A *bundle* consists of generally accepted best practices needed to effectively and safely care for patients undergoing particular treatments with inherent risks.[36] Bundling essential practices is an implementation strategy, with the idea that, when combined, the practices will considerably improve patient care outcomes. It is a cohesive unit of steps, i.e., all components must be completed to succeed; it's all or nothing. A *bundle* should be small and straightforward.[36] The *bundle* approach is growing in popularity and is quickly becoming a standard in healthcare quality improvement strategies.

Even though a SSI-bundle will consist of modifiable processes, and the PREZIES surveillance currently focuses on non-modifiable risk factors, we think that the value and power of *bundles* will justify including them in the surveillance. However, beforehand we should consider whether the increase in work-load for ICPs, to collect information regarding all elements included in the bundle, is acceptable. By including a bundle of process measurements in the SSI module, and thus collaborating with the new national safety program, the recognition of PREZIES might increase.

After studying the results of an intervention, new plans can be invented, which brings you back to the first step of the *Plan – Do – Study – Act* cycle. This shows that infection control is a continuous process, with each change in infection prevention activities providing material and evidence for the next quality improvement. Surveillance is a useful instrument to guide this process in order to prevent healthcare associated infections. Recommendations for the PREZIES network and for the hospitals in order to optimize the SSI surveillance have resulted from the studies described in this thesis.

Recommendations for the PREZIES network:

- Restrict SSI surveillance to 'indicator procedures'.
- Make postdischarge surveillance mandatory according to the recommended method.
- Keep validating the surveillance in all participating hospitals continuously.
- Include bundles of process measurements in the surveillance.
- Cooperate more often and more closely with other healthcare improvement initiatives.

Recommendations for the hospitals:

- Appoint more ICPs for the execution of surveillance (i.e., invest in human recourses and continuous education).

- Use electronically available data as much as possible, to minimize the work-load.
- Set targets before starting surveillance and switch the surveillance to another surgical procedure when the SSI rate has decreased below the target.
- Use the surveillance results extensively for improvements in infection control.
- Ensure close cooperation between the ICP and all other involved healthcare providers, especially surgeons.

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