Master of Public Health Thesis

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Topic: Evaluation of the Norwegian Surveillance System for Infections in Hospital Service (NOIS).

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Abstract

Healthcare-associated infections are a major concern in health care throughout the world, and public health institutions answer to the problem by implementing nationwide surveillance systems. The Norwegian Surveillance System for Infections in Hospital Service (NOIS) was implemented in 2005 to monitor surgical site infections in patients having undergone any one of the most common surgical procedures: Coronary artery bypass surgery, caesarean section, hip replacement surgery, colon surgery, and cholecystectomy. Patients are monitored for these infections through hospitalization plus a period of time after discharge, at which time they stay in touch with the hospital by letter or telephone for follow-up. The NOIS system has not been objectively evaluated since its inception. According to guidelines from the Centers for Disease Control and Prevention (CDC,) the following system attributes of a public health surveillance systems are to be periodically evaluated: Simplicity, flexibility, data quality, acceptability, representativeness, timeliness, stability and usefulness. These attributes are investigated here. A questionnaire survey was constructed and distributed to 52 hospitals of Norway, assessing these attributes through the infectious disease control personnel at the hospital, with a response rate of 69.2% (36 of 52). Hospital routines and practices have been assessed, and representatives from the Norwegian Institute of Public Health (NIPH) have been interviewed to create a complete picture of the functions and benefits of NOIS.

 Results: In general, NOIS appears to be working well for hospitals as well as for NIPH. However, four in ten hospitals reported that the use of NOIS caused no change in clinical practice,. The hospital staff deems that their resources are too limited to prioritize training and education in NOIS activities, that the system would benefit from being electronically automatized as far as possible, that the NIPH websites could be improved, and that the annual reports from NIPH should be published sooner after the survey periods, while NIPH public health officials find that hospitals often submit their surveillance results too late.

Conclusion: Although the NOIS surveillance has obvious benefits in the control of surgical site infections, there is considerable room for improvement in its operation at all levels. It is also indicated that NOIS ought to be evaluated on a regular basis.

List of abbreviations

NIPH   Norwegian Institute of Public Health

HCAI   Healthcare-associated infection

SSI   Surgical site infection

CDC   The Centers for Disease Control and Prevention

NNIS   National Nosocomial Infection Surveillance System

NOIS   The Norwegian Surveillance System for Infections in Hospital Service

ASA   The American Society of Anaesthesiologists

ICP   Infection Control Practitioner

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1. Introduction

1.1. Healthcare-associated infections

Healthcare-associated infections (HCAIs) represent a major worldwide public health problem. They increase morbidity, mortality, and medical costs. In the USA alone, HCAIs account for about 1.7 million of infections, with an extra cost of $4 billion and 99,000 deaths per year[i]. In England, it is estimated that at least 100,000 cases of HCAIs cause 5,000 deaths each year, with an annual extra cost estimated at about £930 million[ii].

Studies on the prevalence of HCAIs in Norway (population 4.7 million) estimate that about 50,000 admitted patients each year will contract an infection[iii]. This inflicts unnecessary suffering on the patients, as well as increased costs on society, mainly due to the extended hospital stay required by patients with HCAIs. The increased length of stay varies from 3,3 days for gynecological procedures to 21 days for orthopedic procedures[iv]. Other costs include additional drugs, isolation, and revision surgeries.

The most frequent HCAIs are of the urinary tract, lower respiratory tract, and surgical wounds. In the context of HCAIs, surgical-site infections (SSIs) have stood out as some of the most common types of infections, accounting for 38% of all HCAIs. SSIs are infections that affect tissues, organs and cavities manipulated during surgery. Diagnosis can occur up to 30 days after the procedure, or even one year after in case of orthopedic surgeries[v].

Currently, about 5.8% of surgical patients in Norwegian hospitals develop a SSI. SSIs have adverse consequences such as longer hospitalization, increased morbidity and mortality rates, and increased antibiotic use[iii,vi]. These infections demand great efforts of prevention. Reduction of the incidence of SSIs can substantially decrease morbidity and mortality and reduce the economic burden for patients and hospitals[v,vii]. For these reasons, both medical professionals and policy makers in hospitals are interested in monitoring SSIs.

1.2. Health surveillance systems

Health care professionals are dedicated to do the patient no harm and reduce the occurrence of HCAIs to the lowest possible level. One element that has been shown to be important in the strategy to reduce the incidence of SSIs, is surveillance. Research has shown that surveillance can substantially reduce the incidence of HCAIs[viii].

Surveillance is defined as "the ongoing, systematic collection, analysis, and interpretation of health data essential to the planning, implementation, and evaluation of public health practice, closely integrated with the timely dissemination of these data to those who need to know[ix]."

Surveillance is designed to:

- Monitor patterns of infectious disease (including their causes,) enabling preventive and control measures to be put in place,
- Prevent outbreaks or detect them early in order to initiate timely action,
- Identify groups of patients at risk of infectious disease,
- Provide information for planning of infection control services, and for allocation of resources.

Surveillance systems can be considered as information loops or cycles of health care providers, as illustrated in Fig. 1.

Figure 1: The surveillance loop[x]
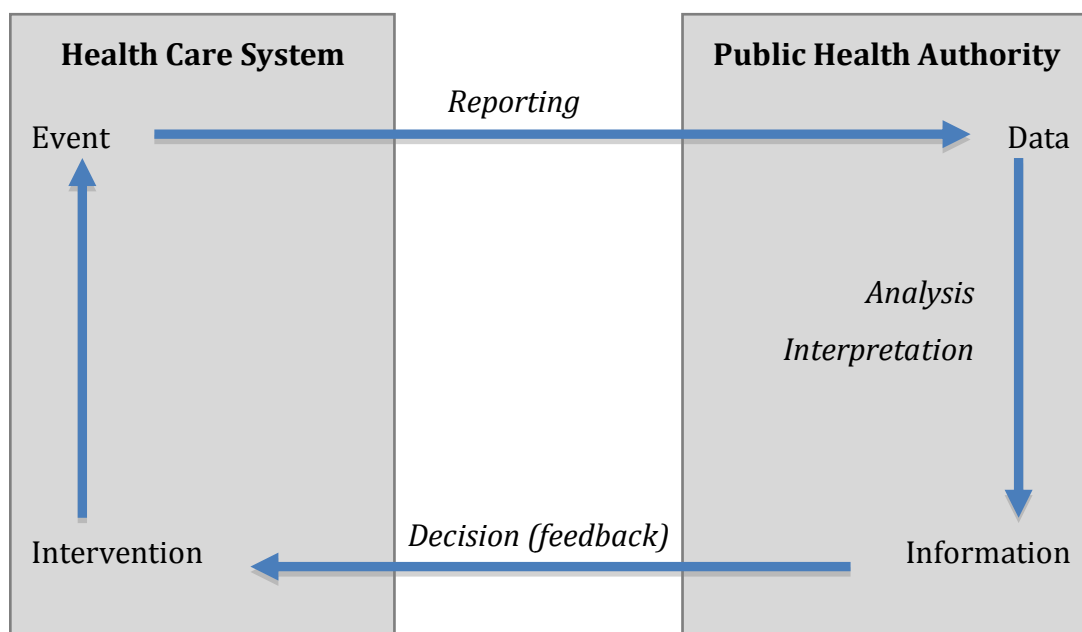
Before data can be used for public health action, health-related data must be collected by the public health system, analyzed, and disseminated to the responsible authorities.

The first large HCAI surveillance network was set up in America by the CDC in 1970, known as the National Nosocomial Infection Surveillance (NNIS) system[xi]. Since then, infection surveillance has been widely adopted throughout the world. The Norwegian Surveillance System for Infections in Hospital Service (NOIS) is the Norwegian counterpart to the NNIS system, and was established in 2005.

2. Norwegian Surveillance System for Infections in Hospital Service (NOIS)

2.1. Overview

As a result of a public health demand for improving the quality of care, the Norwegian Surveillance System for Infections in Hospital Service (NOIS) was implemented in Norway in 2005. NOIS is a mandatory, web-based reporting system, established to monitor SSIs and guide the prevention efforts of infection control practitioners (ICPs.)

NOIS has 57 participating public hospitals across Norway. Each hospital selects the surgery procedures to be surveyed, based on a prioritized list of five different surgical procedures. NOIS was established to determine endemic infection rates, monitor trends, and compare infection rates among hospitals according to standardized criteria. It was also designed to identify outbreaks of infection, and to establish indicators of the quality of services provided by each hospital.

The general goals of NOIS are:

- To develop and implement a reliable, valid, and useful SSI reporting system for hospitals and the public,
- To prevent selected SSIs,
- To generate comparable and accurate infection data, so that hospitals can compare their infections rates with national data.

- To contribute to the development of European surveillance systems for hospital infections.

2.2. Surveillance methodology

In 2005, NOIS started with an incidence module on SSIs. The first surveillance period (NOIS-1) included surgical site infections in five surgical categories, from September through November. The surveillance periods NOIS-2, NOIS-3, NOIS-4, and NOIS-5 were the same three-month period each year from 2006 to 2009.

The participation was mandatory, where hospitals followed the protocol and used the standard and recommended definition criteria of SSIs, developed by the American Centers of Disease Control and Prevention, translated into Norwegian (see Table A, Appendix 1.) The protocols are freely available in electronic format on the Norwegian Institute of Public Health (NIPH) websites (www.fhi.no.) Paper versions of the protocols were sent to all participating hospitals in 2005, 2006, 2007, 2008 and 2009.

NOIS actively monitors all patients referred to the surgical ward of each participating hospital from the time of the surgical procedure until discharge, including a follow-up period of 30 days after discharge (one year in case of implant surgery.) The criteria used to define a SSI, a patient's risk index category, and the different surgical procedures used are those established by the Centers for Disease Control and Prevention (CDC) and the NNIS risk index[xii].

The NNIS risk index was developed in the US in 1991, combining three risk factors, where one point is scored for each of the following[xiii]:

1) American Society of Anesthesiologists (ASA) physical status classification >2 (see Tbl. 2,)
2) Wound classified as either contaminated or dirty/infected,
3) Duration of operation >75th percentile of the specific operation.

Nowadays many countries use the NNIS risk index for risk-adjustment of SSI surveillance data.

2.2.1. Collected information

Over a three-month period each year, surveillance data is collected on all patients undergoing one of five surgical procedures (Tbl. 1.) The hospitals participating in NOIS must submit data from at least one of five surgical procedures, in prioritized order as follows:

Table 1: Surgical procedures included in NOIS

- Coronary artery bypass surgery
- Caesarean section
- Hip replacement surgery
- Appendectomy (until 2008, Colon surgery from 2009)
- Cholecystectomy

The hospital employees responsible for the surveillance are usually, and also in this report, called infection control practitioners (ICPs). ICPs collect data on putative determinants: Age (date of birth,) sex, type of surgical procedure, wound contamination class, ASA-score (Tbl. 2,) elective or emergency surgery, antibiotic prophylaxis, duration of surgery, date of admission, date of surgery, date of discharge.

Table 2: Physical status classification, American Society of Anesthesiologists[xiv]

ASA Classification of 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

Post-discharge surveillance is an important aspect of SSI surveillance. According to the CDC definition, a SSI can develop until 30 days or up to 1 year after surgery. Because the hospitalization of surgical patients is generally shorter

than 30 days, a SSI may develop after hospital discharge. The follow-up of patients after discharge results in more accurate SSI rates.

In NOIS, a post-discharge surveillance is done by a mail-in questionnaire that is sent to the patients approximately 25 days after surgery. Non-respodents are reminded by mail and telephone.

Outcome variables collected include infection status at discharge and 30 days, re-admission or revision because of infection, and death (Fig. 2.)

Figure 2: Surveillance – flow of patients/data
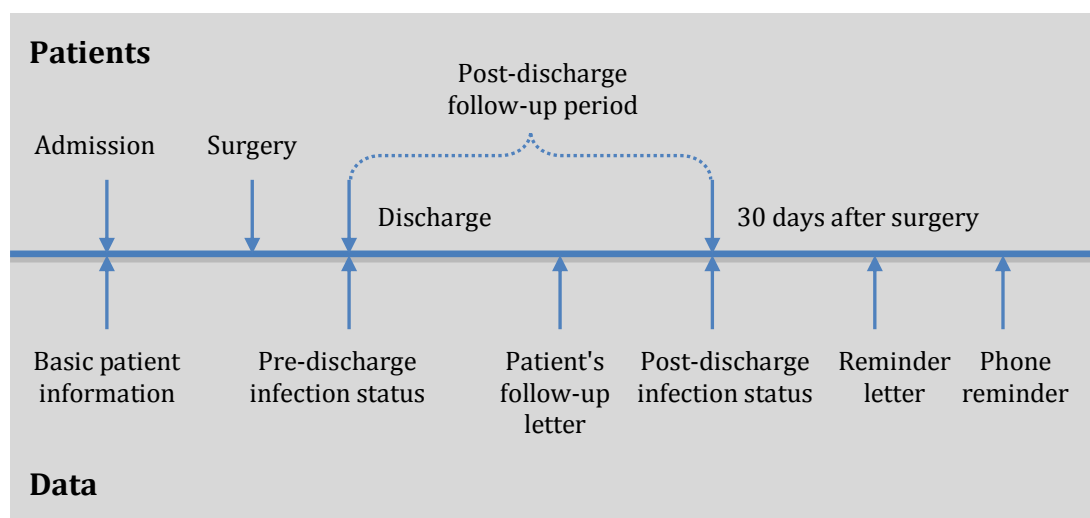
All infections must be confirmed by a physician, except those that are coded as initial diagnoses.

2.2.2. Reporting process and information transfer

ICPs at the hospital gather all incoming reports from the patients and link it to pre-recorded data from the hospital database. After a quality check, the data are sent as one batch to the NIPH, after the three-month period. All SSIs are to be reported, and the patients are encouraged to seek medical assistance if they have an infection.

The patient can diagnose a superficial SSI themselves. More severe infections have to be diagnosed by a doctor.

The collecting of patient data is mostly computerized. Hospitals collect data locally and transfer the anonymized data sets to the national database. Most

hospitals have an infection control module integrated into their computer systems, allowing for a large proportion of data to be extracted electronically. These modules automatically generate patient follow-up letters at the appropriate time.

The national database (and several of the local systems) have integrated quality control programs which check the data sets for faults and inconsistencies.

2.2.3. Feedback and dissemination of information

Every time a hospital submits data, it receives an individual report of their results (SSI rates) in comparison with those aggregated from all participating hospitals. The report also provided SSI rates adjusted for the most relevant risk factors. Furthermore, the feedback report included figures showing the SSI rate for each participating hospital per type of procedure and per type of SSI. Hospitals use these data to monitor local practice, and to initiate further investigation and action should the results indicate untoward rates of infection. An electronic report of the results is published once a year.

An example of the feedback report for SSIs is shown in Fig. 3.

Figure 3: Example of a feedback report from NOIS to one of the participating hospitals in 2008
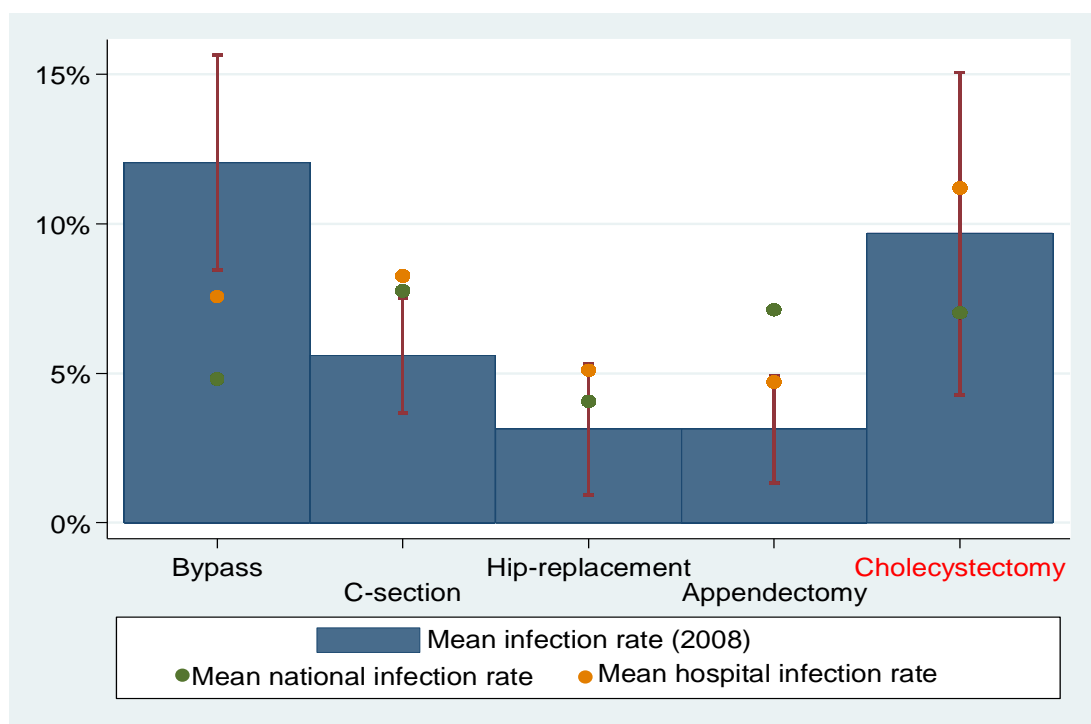
No identifying information is available on patients.

3. Evaluation of NOIS surveillance systems

3.1. Rationale for evaluation of NOIS

The Norwegian Ministry of Health and Care Services' "National strategy for prevention of infections in health service and antibiotic resistance (2008-2012)" is focusing on better control of HCAIs and a more responsible use of antibiotics[xv].

The strategy papers describe the Norwegian Surveillance System for Infections in Hospital Service (NOIS) and its current status. It outlines priorities for improving NOIS, identifies areas where development is required, and sets out some recommended next steps. One of the priorities for further development of NOIS is to "evaluate NOIS in accordance with the standard procedure of evaluating surveillance systems[xvi]."

NOIS has been a mandatory programme of surveillance for 6 years. No evaluation has been done since it was started in 2005.

3.2. Criteria for evaluation

The primary purpose of public health surveillance is to efficiently monitor problems of importance to public health. Every surveillance system should be periodically evaluated to ensure that it is serving a useful public health function and is meeting its objectives.

CDC's original version of surveillance evaluation guidelines was published in 1988. The framework used for this evaluation is detailed in the comprehensive Updated Guidelines for Evaluating Public Health Surveillance Systems[xvii], based on CDC's *Framework for Program Evaluation in Public Health.* This is designed to summarize and organize essential elements of the evaluation, and comprises steps in practice and standards for performing it effectively.

The updated guidelines are based on the tasks in the original version, incorporating suggestions from the public health community[xviii].

3.3. System attributes under evaluation

According to CDCs "Guidelines for Evaluating Public Health Surveillance Systems" the NOIS surveillance system is analysed for the following nine attributes[xix]:

Simplicity

The ease of operation of the system as a whole, and of each component (case definition, reporting procedures, etc.) In general, a surveillance system should be as simple as possible, while still meeting its objectives. A simple system is more likely to provide timely data, requiring fewer resources than a complex system.

Flexibility

The ability of a system to accommodate to changes in operating conditions or information needs, with little extra cost of time, personnel, or funds. Flexibility is necessary when changes occur in case definitions, reporting forms, and procedures. It includes the ability of the system to add new health events.

Data quality

The completeness and validity of the data recorded in the system.

Acceptability

The willingness of individuals and organizations to participate in the system. For example, the acceptability of reporting is greatly influenced by how much time the reporter is required to invest.

Representativeness

Whether the system accurately describes the occurrence of the disease in aspects of time, person and place.

Timeliness

The speed of, or delay between, the steps of the system.

Usefulness

Whether the system makes a difference. We may assess usefulness by answering the following:

- What actions have been taken to date (public health, clinical, legislative, etc.) as a result of information given by the surveillance system?
- Who (which groups of personnel) has used the information to make decisions and take actions?
- What other future uses might the information have?

3.4. Objectives

A comprehensive evaluation of NOIS is to be conducted in order to:

1) Describe the surveillance system in terms of its attributes: simplicity, flexibility, data quality, acceptability, representativeness, timeliness, stability to obtain feedback about the overall operation of the system,
2) Indicate the usefulness of the surveillance system (ie. the relative importance of all output), and whether action taken as result of data obtained meets surveillance objectives,
3) Define recommendations to improve the system's utility and efficiency.

4. Methods

4.1. Scope

The evaluation of NOIS covers all Norwegian hospitals that were participating in surgical surveillance programs from September 2005 to November 2009.

4.2. Methodology reference

The CDC's Updated Guidelines for Evaluating Public Health Surveillance Systems was used as a main reference for the methodology, besides other sources of recommendations for evaluating public health surveillance systems[xx].

4.3. Methods

Three different methods were used in the evaluation: Interviews, a questionnaire, and an evaluation of various written NOIS material. The three methods are described below.

4.2.1. Interviews: Norwegian Institute of Public Health

Open interviews with managers of surveillance data were conducted. Three advisers from NIPH provided information about NOIS and its system operations.

At these interviews, the following questions were asked: What information is collected? Who collects the data? When is the data collected? Who analyses the data? How is it disseminated? To whom is it disseminated? Is the privacy of the patients guaranteed? How is the post-discharge surveillance performed?

4.2.2. Public health and hospital files, documentations, and routines

Surveillance protocols for hospitals and other relevant documents, including reports and publications, are reviewed, as well as functions of the electronic surveillance tool and its database content from 2005 to 2009. The human resources required to run the surveillance at different levels are described as well.

4.2.3. Questionnaire survey for the users of NOIS

A structured electronic questionnaire was sent to one ICP in each of the 52 main hospitals of the approximate 57 in Norway[xxi].

All 52 participating hospitals were contacted to complete the survey, consisting of 28 questions and several sub-questions. We started the work of creating this questionnaire in October 2010. The questionnaire is developed specifically for this project and has never been used before. The complete survey questionnaire is to be found in the appendices of the present work.

The final version of the questionnaire consists of six sections. Section 1 is designed to assess the general characteristics of hospitals, including the staffing of infectious disease control personnel and local procedures for monitoring surgical procedures. Section 2 assesses the organization of the hospital, and to what degree surveillance and other NOIS-related tasks are included in the hospital routines. Local procedures, management of patient data, and handling of NOIS-relevant data are assessed as well.

Section 3 assesses the definitions of infections. Section 4 evaluates the quality, handling, and distribution of NOIS reports. Section 5 asks users to evaluate how NIPH manages NOIS, and about their experiences with searching for information about NOIS on the NIPH website. The quality and purpose of Overvåkningsdagene (Surveillance Days) is assessed as well.

Section 6 asks how NOIS data is used to prevent infections in the hospital, and assesses the results of the surveillance.

The construction of the survey questionnaire was performed by master student Liudmyla Fagerbakk, University of Tromso and senior advisor Hanne-Merete Eriksen at NIPH, with contributions from researcher Sidsel Graff-Iversen at NIPH.

The first version of the questionnaire was evaluated by a selected infection control nurse, and then revised. After that, the QuestBack[xxii] program was used to create an electronic version of our questionnaire. Then, in QuestBack form, the questionnaire was sent to everyone in the NIPH group "Infection Control in Health Care" for testing, and then finally revised.

On February 25th 2011, the finished electronic survey was distributed nationwide to the 52 participating hospitals. Hospitals in Norway are organised into hospital trusts (HT, "Helseforetak") within a health region. Sometimes one ICP is responsible for one hospital, and in other cases one ICP works for two or three hospitals within a hospital trust. The questionnaires were sent to the IPCs who are NIPH's contact persons at each of the hospital. The information asked for in the survey was for the NOIS-5 period (September to November 2009.) One response alternative per item was requested. Deadline for answers was March 22th. An initial invitation letter, an electronic reminder and a last-chance letter[xxiii] was forwarded if no response had been made. By March 22, 2011, a total of 36 of the 52 hospitals had responded, giving us a 69.2% response rate.

Once all responses were received, the QuestBack program generated reports with graphics and tables. Reports from QuestBack were exported in Microsoft Word file format, with graphics and tables to illustrate the results.

4.4. Process evaluation

The process evaluation was conducted in February-March 2011 and assessed daily surveillance activities, including attributes such as simplicity, flexibility, data quality, acceptability, representativeness, timeliness, stability and usefulness by three methods, as describe above. The survey is newly developed for this project. As such, surveillance attributes such as reliability, sensitivity and positive predictive value (PPV) of NOIS was beyond the scope of this evaluation.

Table 3: Checklist for the evaluation of NOIS system attributes.

Surveillance attributes	Sources of information
Simplicity	Survey questions:
	Does the hospital use the definitions of postoperative wound infections given in the NOIS framework?
	Have you looked up information about NOIS on NIPH's website?
	How often do you find the necessary information about NOIS on the NIPH's website?
	Do you feel that any information is lacking from NIPH's website?
	What kind of information do you feel is lacking from NIPH's website?
Flexibility	Interview with managers, reports, survey questions:
	Which of the surgical procedures performed at the hospital were monitored in NOIS in fall 2009?
	Does the hospital monitor other surgical procedures that are not included in NOIS?
	Would the infectious disease control personnel want any other surgical procedures to be monitored in NOIS?
	Which other surgical procedures would you like to be included in NOIS?
	Specify other surgical procedures monitored by the hospital.
Data quality	Interview with managers, reports, survey questions:
	During the surveillance period of 2009, how much time did infectious disease control personnel spend on the data quality check?
	During the surveillance period of 2009, how often did infectious disease control personnel quality-check NOIS data against the following sources?
	Does the hospital use an electronic patient administration system which creates lists of readmissions and reoperations after surgical procedures?
	Does the hospital have an electronic infection module which collects NOIS data from patient files or other data sources at the hospital?
	Do you add any of the NOIS variables manually to the electronic

	infection module?
Acceptability	Survey questions: NOIS reports, definitions of postoperative wound infections:
	How often are there formal meetings with infectious disease control personnel in which NOIS is discussed?
	Has the infectious disease control personnel at your hospital participated in one or more of Overvåkningsdagene [Surveillance Days] since NOIS started?
	Did you find the content of Overvåkningsdagene [Surveillance Days] to be?
	Which themes should be presented at Overvåkningsdatene [Surveillance Days]?
	Is there a further need for training and support in NOIS surveillance from NIPH
	In which areas is there a further need for training and support?
Representativeness	Interview with managers, reports, documents, NIPH websites
Timeliness	Interview with managers, reports, documents, NIPH websites, e.g. figures submitted within the deadline. Survey questions:
	Do you have any suggestions for improvement of the NOIS reports from NIPH?
Stability	Reports, documents, NIPH websites, the proportion seeking postponement due to computer problems
Usefulness	Survey questions:
	Has the NOIS surveillance led to increased attention to postoperative wound infections among personnel in the hospital wards?
	Have you introduced new, or revised existing, measures against infectious disease as a result of the NOIS surveillance?
	What measures against infectious disease has been introduced or revised as a result of the NOIS surveillance?
	Do you have any other comments to NOIS?
Human resources	Interview with managers, reports, survey questions:
	Number of employees working with infectious diseases at your hospital, and their position.
	Do any employees in infectious disease control have a reduced

	position?
	How many employees within infectious disease control have a reduced position? Specify the position and position percentage of the individual employees.
	Is the organization and responsibility distribution equivalent for all the surgical procedures monitored in NOIS at the hospital?
	During the surveillance period of 2009, how much time did infectious disease control personnel spend on the following NOIS tasks?
	During the surveillance period of 2009, how much time total did other hospital personnel spend on the following NOIS tasks?

Ethical approval

This project does not require an ethics submission.

5. Results

5.1. Evaluation of NOIS' system attributes

5.1.1. Simplicity

In our survey, we assessed simplicity by asking how the definitions of postoperative wound infections are used, and, if unclear, whether users would seek the necessary information.

In all 35 (97.2%) of respondents use the definitions of postoperative wound infections given in the NOIS protocol, and one (2.8%) had adjusted them to local standards. One comment explained how they have adjusted the definitions: "*We use a separate scoring form, based on secretion, redness, pain.*"

Also, we asked users to give some comments as to the definitions: 7 hospitals suggested that *it is uncertain how closely doctors (primary physicians and in the hospitals) follow the definitions; we often find that surgeons are not familiar with the definitions even if they are available; patients' self-diagnosed infections should be removed.*

5.1.2. Flexibility

The NOIS protocol is revised annually, and the NOIS reference group meet twice a year to discuss the surveillance system and to suggest improvements to the protocol.

During the five surveillance periods, the below changes were made to the protocols[xxiv].

NOIS-2: Clarification of post-discharge surveillance is made, along with clarifications of the terms for follow-up and revision operation, and NOMESCO-codes.

NOIS-3: Revision of hip replacement is removed from the monitored procedures, the patient letter is revised, and a new variable for health authorities organization number is introduced.

NOIS-4: New variables: EuroSCORE (voluntary,) height and weight, diabetes were included.

NOIS-5: Appendectomy is removed and colon surgery included in the surveillance. Two new mandatory variables are included: ICD-10 and euroSCORE (only for bypass surgery.) Changes are also made in how NOMESCO code is to be reported.

Response to survey: *Is the system flexible enough to adapt to new sources of information, new types of disease?*

Figure 4 illustrates which surgical procedures were performed in 2009. The majority of the 36 hospitals who responded to this question, 34 (94.4%) performed hip replacement surgery, 32 (88.9%) cholecystectomy, 29 (80.6%) caesarean section and 28 (77.8) colon surgery. Only 6 (16.7%) hospitals performed coronary artery bypass surgery.

Figure 4: Which surgical procedures were performed at the hospital in fall 2009?
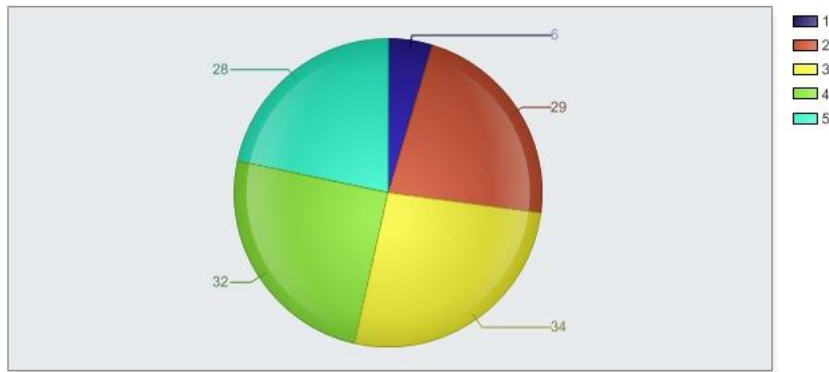
Legend
1. Aortocoronary bypass surgery
2. Caesarian section
3. Hip replacement surgery
4. Cholecystectomy
5. Colon surgery

The targeted surgical procedures vary between the hospitals who perform surveillance for surgical site infections. The majority of hospitals (N30, 83.3%) monitor hip replacement surgery, 26 (72.2%) caesarean section, 14 (38.9%) cholecystectomy, 7 (19.4%) colon surgery, and 5 (13.9%) coronary artery bypass surgery.

Figure 5: Which of the surgical procedures performed at the hospital were monitored in NOIS in fall 2009?
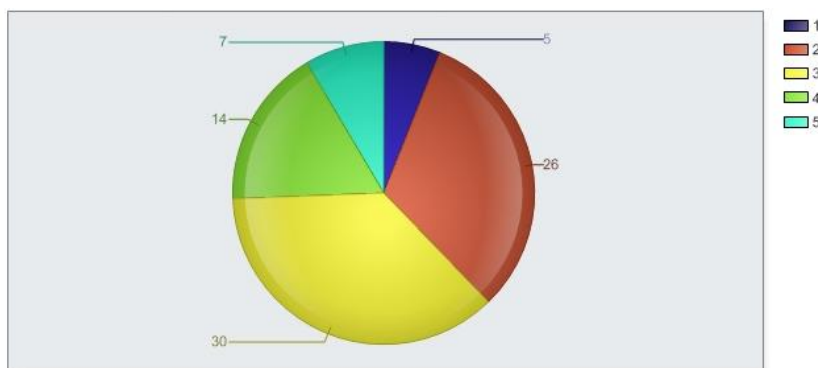
Legend
1. Aortocoronary bypass surgery
2. Caesarian section
3. Hip replacement surgery
4. Cholecystectomy
5. Colon surgery

18 hospitals (50%) monitor other surgical procedures that not included in NOIS.

The majority of these procedures are knee replacement surgeries, while some hospitals monitor all surgical procedures performed.

In order to further facilitate the flexibility of NOIS, we asked if the ICPs would want any other surgical procedures to be monitored in NOIS. Nearly half (41.7%) of the respondents want other surgical procedures to be monitored, 12 (33.3%) answered "no", and 9 (25%)were uncertain. When we asked users to indicate which of the additional categories of surgical procedures they would like to have under monitoring in their hospital, the most frequently cited procedures were knee replacement surgery (N10,) colon surgery, and cholecystectomy (N2.)

5.1.3. Data quality

Data received by NIPH undergoes several quality checks before being accepted into the database. Despite this, in NOIS-5 the number of missing values for some variables was high (Tbl. 4.)

Table 4: Systematic differences and missing values (2009)[xxv]

Variables	Number of missing values
ASA (physical status classification)	294
Wound contamination class	618
Elective or emergency surgery	981
Antibiotic prophylaxis	4037

The data of variables sex, date of birth, duration of surgery, elective or emergency surgery, wound contamination class, and antibiotic prophylaxis was not complete in 4474 places. Antibiotic prophylaxis was the least complete variable.

Wherever data inconsistencies were identified, hospitals were contacted, the discrepancies were discussed, and if records needed to be modified, the hospitals edited the data.

Survey responses on the quality checking of data:

The 36 ICPs report that they check NOIS data against the following sources:

- Patients' paper records (medical journals) – the most commonly used source – 14 ICPs examined these always, 19 examined them often, and three examined them sometimes;
- Operation schedules – 14 ICPs examined these always, 13 often, 2 sometimes, 2 rarely, 5 never;
- Laboratory reports – 7 examined these always, 11 often, 8 sometimes, 2 rarely, 8 never;
- Records of antibiotics use – 4 examined these always, 7 often, 10 sometimes, 6 rarely, 8 never;
- X-ray results – 6 examined them sometimes, 17 rarely, 13 never;
- Other sources – 3 examined them always, 2 often, 6 sometimes, 4 rarely and 11 never.

Among other sources, 15 responders cited anesthesia records and the patient administration system.

Most ICPs undertake regular and timely examination of surveillance data – mainly patient records and operations schedules. Some sources, such laboratory reports and antibiotics use records, were never examined in 8 hospitals.

We asked whether the hospital uses an electronic patient administration system which creates lists of readmissions and reoperations after surgical procedures. Seven hospitals (17.1%) use one system for both readmissions and reoperations, 2 hospitals (5.6%) use a system for readmissions only, and one hospital use a system for reoperations only. Overall, 13 hospital (36.1%) have no system of neither readmissions nor reoperations. 36.1% (N13) of respondents reported that they don't know about this system.

The majority of hospitals (N25, 71.4%) reported that they have an electronic infection module which collects NOIS data from patient files. Almost one third (28.6%) report that they do not have an electronic infection module at all.

When we asked hospital services if they add any of the NOIS variables manually to the electronic infection module, the majority of the 25 respondents to this question (N22, 88%) do it manually, whereas only 3 (12%) have an automatic system for all variables. In their comments, antibiotics prophylaxis is the most commonly cited variable that is manually added. Some cited all variables.

5.1.4. Acceptability

Participation in NOIS activities was used as an indicator of its acceptability.

We asked: How often are there formal meetings with infectious disease control personnel in which NOIS is discussed?

It turns out that only 5.9 % have monthly meetings with the surgeon, 8.8 % every three months, 14.7% every six months, and 17.6% annually. More than half of the ICPs never had meetings with the surgeons. Only one third of respondents reported that they discuss NOIS problems yearly with the surgical administration, hospital administration or health care business administration. From 50% to 70% never had meetings with those categories of staff (Fig. 6.)

Figure 6: How often are there formal meetings with infectious disease control personnel in which NOIS is discussed?
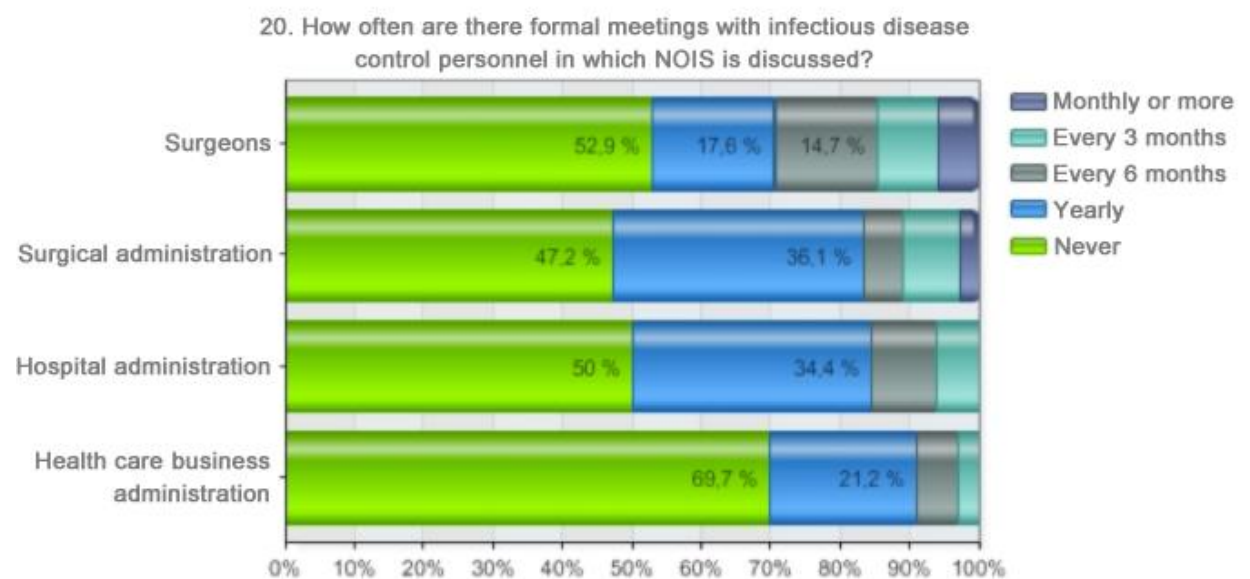
When asked about the NOIS reports, users respond that these are disseminated to at least three groups of clinicians/managers within the hospital. The majority of hospitals (N28, 84.8%) forwarded the results to the surgical wards, 26 (81.3%) to the hospital administration, and 15 (68.2%) to other clinical managers (see Fig. 7.)

Figure 7: Distribution of NOIS reports

36. Do the infectious disease control personnel forward the NOIS reports from the Norwegian Institute of Public Health (NIPH) to:
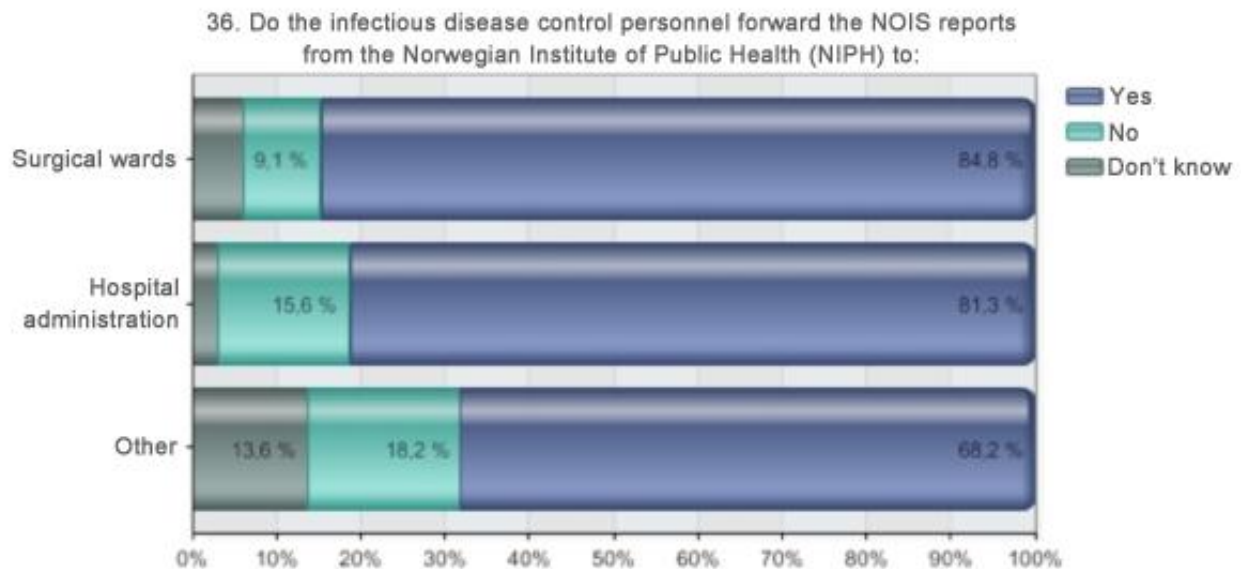
Six hospitals report their surveillance results to quality/risk managers committee, four report to infection control committees and key clinical managers, and two publish the data to their intranet.

The majority of responders (N25, 71.4%) find that the information in the reports is sufficient, 3 (8.6%) think it is too scarce. Seven (20.0%) were unsure.

In our survey, we asked how often in one year the NOIS reports from NIPH are used in education at the hospital. Almost half part of the respondents (44.4%) used the NOIS reports once or twice; 19.4% used them 3-4 times; 16.7% of respondents used them more than 4 times. 19.4 % of hospital services don't use reports from NIPH in training and education.

Every year all infection control personnel in Norway are invited to a one-day assembly to focus on NOIS. ICPs from 28 (77.8%) hospitals participated in one or more of Overvåkningsdagene [Surveillance Days] since NOIS started. ICPs from 8

(22.2%) hospitals did not participate. 39.3% of all participants found the contents of Overvåkningsdagene [Surveillance Days] very satisfactory, 60.7% found it rather satisfactory.

The majority of the 28 users who answered this question (N25, 89.3%) suggested that there should be presented more examples of use and interpretation of data in hospitals during the "Surveillance Days". 20 (71.4%) would like to receive information about casuistics, understanding of definitions of postoperative wound infections, and analysis of own hospital data. 16 (56.1%) of users think that there should be a theme of understanding the variables included in the NNIS risk index.

5.1.5. Representativeness.

Hospitals

According to Statistics Norway, there were 57 public hospitals in Norway in 2008[xxvi]. Data from the electronic database spanning from September 2005 to November 2009 was used to assess the representativeness of the surveillance at national level.

Table 5 shows the participation of hospitals and number of operations per three-month period/year. We find that the number of participating hospitals increased from 30 in the first period to 38 in the second period. One factor may be that Norwegian hospitals began to prioritize the implementation of computer-based systems to handle patient records. In order to facilitate data processing, hospitals without computerized data collection systems were exempted from participation in NOIS-1 and in NOIS-2. From 2007, most hospitals had computerized data collection systems implemented, and participation was 93%.

Table 5: Participation of Norwegian hospitals in NOIS from 2005 to 2009.

Year	Total no.	%	Total no. of operations	Patients followed (%)
2005	30	53	2468	88
2006	38	67	3664	92
2007	50	88	4405	91.8
2008	52	91	5340	87
2009	53	93	6051	93

Overall, 92% of all patients operated during the surveillance months were followed for at least 25 days after surgery.

5.1.6. Timeliness

Data are most useful when the time between data collection and availability for review is the shortest.

The participating hospitals send data to NIPH at the end of the three-months surveillance period. The deadline has differed for different NOIS periods; NOIS-1 (2006): February 30th; NOIS-2 (2007): February 2nd; NOIS-3 (2008): February 18th; NOIS-4 (2009): February 7th; NOIS-5 (2010): March 1st. Most of the participating hospitals (80%) submitted their data within the deadline, but some of them needed to be reminded by e-mail (20%.) Even after that, some of them delivered their reports with great delay. This is was no information available in NIPH about the number of hospitals seeking postponement due to computers problems.

In NIPH, it takes approximately three months to check the data quality, clarify errors, and write and publish the annual report. The results from NOIS-1 were published on NIPH's website on June 1st 2006, NOIS -2 on June 15th 2007, NOIS-3 on June 25th 2008, NOIS-4 on July 3rd 2009, and NOIS-5 on September 29th 2010.

In our survey, 12 ICPs gave suggestions for improvement of the NOIS reports from NIPH, indicating that *the results are returned too late, making it difficult to*

use it in training, users miss an individual feedback on their own numbers, tips for improvements, and comments; they would like more text in the reports.

5.1.7. Stability

There was no downtime during the surveillance. All five surveillance periods were completed as planned. Annual surveillance reports are usually published on time. There has been only one period, 2010, where the annual report was delayed (see point 5.1.3.)

5.1.8. Usefulness

Usefulness can be indicated by describing the actions taken as a result of data collected by the surveillance system. Only information that leads to improvements in practice or interventions is regarded as useful.

Table 6: Does the system lead to improved clinical practice? (in % of respondents)

Does the system lead to…	Yes, to a great degree	Yes, to a certain degree	No change	Don't know	N
…Increased attention to postoperative wound infections among personnel in the hospital wards	19.4%	44.4%	19.4%	16.7%	36
…Increased attention to postoperative wound infections in the administration of the hospital	19.4%	38.9%	27.8%	13.9%	36
…Initiation of specific measures against infections	11.1%	44.4%	36.1%	8.3%	36
…Evaluation of the effect of measures taken to control infections	3.1%	39.4%	42.4%	15.2%	33
…Better communication between surgical wards and infectious disease control wards	11.4%	37.4%	40.0%	11.4%	35
…Identification of infectious outbreak	5.7%	25.7%	62.9%	5.7%	35

Table 6 shows that about 60% of users report improved clinical practice to a greater and a certain degree. For those hospitals, the most frequently cited benefit was an increased attention to postoperative wound infections among personnel in the hospital wards and the hospital administration, and initiation of specific measures against infections. 48.8% of users noticed better

communication between surgical wards and infectious disease control wards, and around 30% were able to identify infection outbreak.

Around 40% of users did not find the surveillance useful – they answered that the use of NOIS caused no change in clinical practice.

17 hospitals (48.6%) introduced new, or revised existing, measures against infectious disease as a result of the NOIS surveillance. As a result of the NOIS surveillance, the following clinical areas were changed or revised: preoperative care (7 comments,) antibiotic prophylaxis (5 comments,) and surgical techniques (3 comments.)

A lot of useful information about NOIS is available on the Norwegian Institute of Public Health (NIPH) websites (www.fhi.no.) Most of the hospitals (N33, 91.7%) reported that they looked up information about NOIS on NIPH's website. A few hospitals (N3, 8.3%) do not use NIPH's websites as source of information. Overall, 28 (84.8%) of hospitals indicated that they often look up information, 4 (12.1%) always, and one (3%) of respondents rarely. 21.2% of 33 users feel that information from NIPH's website is lacking, for 30.3% information is sufficient, and 48.5% were unsure.

When we asked what kind of information seems to be lacking from NIPH's website, 7 hospitals responded, and of these 4 suggested there should be more casuistics; 3 that there should be more information about the understanding of definitions of postoperative wound infections, 2 that there should be more information about the understanding of the variables included in the NNIS risk index, and 1 that there should be more questions and answers.

Finally we asked if the user had any other comments to NOIS. 23 ICPs provide the following comments and suggestions:

The monitoring of SSIs are important; exciting but demanding; 3 months' surveillance is too little; introduction of variables that cannot be retrieved electronically is not desirable; it would be an advantage to compare own data with that of other hospitals; changes in protocol must be provided in good time; reports

from NIPH come too late, electronic tolls are lacking; data collection is a burden; not enough resources in the hospital.

5.1.9. Human resources (part of system operations)

Six persons are responsible for running the surveillance at national level: five advisors in NIPH and one external IT consultant. None of them work with NOIS full-time.

The maintenance of the electronic tool, including data quality assurance, annually require 25 months of work of these six people. This includes implementing the current monitoring period, collecting, quality control, and processing of data from previous periods, reporting of the results back to the hospitals and other relevant parties, publishing results on NIPH's website (www.fhi.no,) preparing new protocols, training new employees, and disclosing data.

The development of NOIS requires annually 10 months of work of the same group of six people.

Survey responses on staffing and time dedicated to infection control:

Infection control teams in hospitals are normally made up of medical staff with the necessary training. We asked about the staffing of ICPs and doctors with infection control responsibilities. In 28 hospitals infections control employees were doctors: among them 25 hospitals have 1 medical doctor, 2 have 2 medical doctors, and 1 have 3 medical doctors.

In 34 hospitals infection control employees were nurses: among them 14 hospitals have 1 position, 12 have 2 positions, 4 have 3 positions, 1 have 4 positions, 3 have 5 positions.

In 10 hospitals other hospital personnel were represented: 7 hospitals have 1 position, 1 hospital 2 positions, and 2 hospitals 5 positions. In the comments we find that the other personnel included in the infections control team are secretaries (2,) advisers (5,) consultants (2,) microbiologists (4,) TB coordinators (2,) and a scientific officer (1.)

In our survey we asked whether any employees with infection control responsibilities have a reduced position. 80.6% (29) of respondents answered that they do. Only 19.4% (7) work full-time as ICPs.

Of those in a reduced position, 8 infection control doctors are employed in a 20% position, 4 work 40%, and 3 work 50-60%. A proportion of infection control nurses work less than full-time: 6 work 50-60% and 7 work 75-80%.

One important step towards ensuring that resources are used well is to clearly define the role and responsibilities of ICPs. We asked who in the hospital are responsible for the different surveillance activities. Table 7 shows how responsibilities for various NOIS activities are distributed amongst the hospital staff. The expected pattern was reflected in the survey results: In a majority of cases the infection control nurse is responsible for most of the surveillance activities.

Table 7: Responsibility distribution for NOIS-related tasks at the hospital (in % of respondents)

NOIS-related tasks	Infection control doctor	Infection control nurse	Surgical nurse	Surgeon	IT personnel	Secretary	Nobody	N respondents
Data collection	3.4%	55.2%	10.3 %	3.4%	–	27.6%	–	29
Transmission and recording of patient letter	–	44.8%	6.9%	–	–	48.3%	–	29
Data quality check	6.9%	86.2%	3.4%	–	–	3.4%	–	29
Data analysis	17.2%	62.1%	-	13.8%	-	-	6.9%	29
Interpretation/use of data	37.9%	31.0%	-	24.1%	-	-	6.9%	29

Respondents were then asked to estimate the proportion of their work time spent in each of the six categories of NOIS activities: 1) Training, 2) Data collection, 3) Follow-up of patients after discharge, 4) Data quality check, 5) Working out own NOIS reports, 6) Interpretation/use of data.

Table 8: Reported proportions of time spent by ICPs on surveillance activities (in % of respondents)

Surveillance activities	0 days	1-2 days	3-4 days	5-7days	8-14 days	15-28 days	>28 days	N
Training	28.6%	45.7%	14.3%	2.9%	8.6%	0.0%	0.0%	35
Data collection	5.6%	11.1%	25.0%	13.9%	22,2%	11.1%	11.1%	36
Follow-up of patients after discharge	14.7%	17.6%	14.7%	17.6%	20.6%	2.9%	11.8%	34
Data quality check	0.0%	22.2%	16.7%	25.0%	19.4%	8.3%	8.3%	36
Working out own NOIS reports	17.1%	45.7%	17.1%	8.6%	5.7%	5.7%	0.0%	35
Interpretation/use of data	14.3%	40.0%	28.6%	11.4%	2.9%	2.9%	0.0%	35
Other NOIS related work	21.2%	33.3%	9.1%	9.1%	15.2%	9.1%	3.0%	33

The majority of users (>40%) spent 1-2 days for important surveillance activities such as training, working out own reports, and interpretation of data.

There were wide differences between the hospitals in the proportion of time spent on some surveillance control activities. The widest variation was in the amount of time spent on surveillance – some hospitals reported 15-28 days spent on surveillance, while others reported 1-2 days.

About 90% of users reported that they spent some time on other NOIS-related work: Cooperation with IT personnel, providing ongoing training and awareness education for employees in the hospital service; drawing up guidelines and revising procedures for infection control; providing advice.

In our survey we asked how much time other hospital personnel spend on the same NOIS tasks during the entire surveillance period. Overall, 28 (77%) hospitals indicate that other hospital personnel spend time on surveillance activities, but that the proportion of time is not very large. One hospital reported that it was difficult to accurately assess the proportion of time spent by other medical personnel on the various activities.

When hospital ICPs were asked how much time they spent to create one file with NOIS data, the response was that they spent too much time on it: Answers varied from 5 to 40 hours during one surveillance period.

6. Discussion

The surveillance system of surgical site infections NOIS for periods 2005-2009 appears, in general, to be working well for hospitals and patients as well as NIPH.

We find that the NOIS surveillance acts to increase awareness of infection control issues within hospitals: For many hospitals it has provided an important stimulus for initiating a review or change of clinical practice.

However, a response was missing from 16 of the total 52 hospitals(69.2% response rate) and around 40% of hospital ICPs answered that they did not consider NOIS to have practical consequences for their infection control work.

System operations

ICPs, physicians, nurses and other personnel are involved in data collection and other surveillance activities to different extents in different institutions. Responsibilities for the various surveillance activities were appropriately allocated to a range of clinical staff, although some hospitals did not give responsibilities to all relevant ICPs.

The users of the system show how the responsibilities for NOIS activities are distributed between medical staff in a hospital. This pattern was reflected in the survey results. In majority of cases, the infection control nurse is mainly responsible for surveillance activities. Physicians were mainly involved in data interpretation and use of the result.

Training of the personnel involved is crucial, but 30% of respondents do not spend time on training and education.

The number of persons and personnel time needed to run the system at local and national levels is favourable, and it seems that more resources are needed for this purpose. The staffing number required to support effective infection control activities depend on the size of hospital. In 1985, the SENIC study recommended 1 full-time ICP per 250 occupied beds[xxvii].

A majority of ICPs work in reduced position (80.6% of respondents.) Because most doctors work in reduced position as well, they might not have enough time available for infection control.

This was illustrated by comments such as: "In practice we have 0% employed infection control doctors" and "There is a huge potential in NOIS to improve patient safety and quality of services at all hospitals. Help us get the resources to use it!"

Considering the large cost of HCAIs, for patients, hospitals and the total health budget in Norway, a system like NOIS should get priority. It follows that regularly external evaluations of NOIS should be performed.

System attributes

Simplicity: Despite its complexity, NOIS is reported to be relatively easy to operate on a daily basis.

Flexibility: The system has routine mechanisms for review and adaptation to the changing needs of the decision makers. Through previous revisions, it has proven to be flexible to the introduction of new demands.

Some hospitals monitors not only the surgical procedures included in NOIS: 50% of users monitor other surgical procedures as well. 41.7% want other surgical procedures to be included, and a number of users request that additional categories of surgical procedures are added to the system. The survey results show that there is a demand for extension of the surveillance, where the most frequently cited procedure is knee replacement surgery.

"In the future, investment in information technology such as handheld computers and web-based data entry would serve to enhance local data entry and analysis, facilitate the surveillance process and increase its flexibility for users[xxviii]."

Data quality: In our survey, the majority of hospitals (N25, 70.6%) reported that they use an electronic infection module that collects NOIS data from patient files. Conversely, almost one third (29.4%) do not use an electronic infection module.

The majority of 25 respondents (N22, 88%) add some NOIS variables manually to the electronic infections module. Only 3 hospitals (12%) use an automatic system for all variables.

In their comments, respondents cited that the variable that is most commonly added manually is *antibiotics prophylaxis*. As we see in *Table 4: Systematic differences and missing values (2009)* this variable is the least complete, indicating a decreased reliability of manually added data.

Most ICPs undertake regular and timely examination of surveillance data, mainly patient records and operations schedules. However, some sources, such as laboratory reports and antibiotics use records, were never examined in 8 hospitals.

Acceptability: The participation rate in NOIS activities and the time spent on NOIS-related tasks at the hospitals indicates that the participation in NOIS activities is acceptable to users. On the other hand, many referred to limited time and resources. Increased use of automated rather than manual routines may help to increase the acceptability as well as dataquality and timeliness.

Representativeness: Hospitals participating in NOIS was 93% in 2009, and 92% of surgical patients were followed for at least 25 days after surgery. Norwegian hospitals are well represented in NOIS surveillance and the high participation makes the data more reliable. However, the missing response from 16 hospitals in the present evaluation indicates that NOIS-related work may have a low priority in some hospitals.

Timeliness: "The increasing use of electronic data collection from reporting sources and via the Internet (a web-based system,) as well as the increasing use of electronic data interchange by surveillance systems, might promote timeliness[xxix,xxx]."

There were delays in reporting on national and local level. Surveillance data was received at the regional level from the national level annually, and further disseminated to at least tree groups of clinicians. Some of the users we surveyed

felt that the reports are released too late. If earlier, it would be easier for hospitals to use them in training and education.

However, on the national level the reason for delay often was that the data from the hospitals was submitted too late.

In our survey, 12 ICPs give suggestions for improvement of the NOIS reports from NIPH. It is indicated that users miss individual feedback on their own numbers, tips for improvements, and comments. They want more text in the reports. Respondents also indicated that they want to be able to compare their own incidence rates with the other hospitals in the country.

Stability: NOIS is a stable system without glitches or frequent shutdowns.

Usefulness: NOIS is a complex system, it is therefore important that users can seek and find information easily at NIPH's websites. Survey responses indicate that NIPH's websites are used extensively (97.1%) by ICPs in daily practice, and that more than a fifth (21.2%) of users find that the information is insufficient. Almost half (48.5%) of respondents had no opinion about the comprehensiveness of NIPH's websites, indicating that it doesn't serve their purposes well enough. On this point improvement may be made with relatively small resources.

The majority of users (60%) report improved clinical practice to a certain and greater degree. The most frequently cited benefit was an increased attention to postoperative wound infections among personnel in the hospital wards and the hospital administration, and initiation of specific measures against infections.

Almost half (48.8%) of users noticed better communication between surgical wards and infectious disease control wards. Around 30% were able to identify infection outbreak.

However, when questioned, about 40% of users report that NOIS has not lead to changes, an answer that may reflect that they do not find the system useful.

Surveillance is a time-consuming process, and in the case of HCAIs it becomes more difficult with earlier discharge of patients. If systems for local data entry

and electronic data transfer could be developed, however, surveillance can be done by far more efficiently than at present.

Our numbers indicate a demand for training in interpreting and using surveillance data, as well as a need for more help and advice from NIPH. The development of a training programme for ICPs could be of benefit.

Strengths and weaknesses of the evaluation method

For strengths we will point to the fact that we used a method built on system attributes according to WHO's recommendations. Second, the process involved both the staff at NIPH and nationwide hospital staff, with a rather high response rate. In itself, the involvement of relevant staff may lead to improvement of the NOIS system and collaboration. Further, the questionnaire allows hospital staff to add comments, opinions and suggestions of their own.

For weaknesses, we will mention that the questionnaire was constructed and used for the first time in the present evaluation. We found, in retrospect, that we should have asked some additional questions, and that some questions could be omitted. The questionnaire could be improved for future evaluations by inclusion of some of the issues that were now brought up by the respondents as commentary.

In all, 16 hospitals did not respond, mainly small hospitals with fewer than 100 beds. What do we know about the respondents and nonresponders? Hospitals in Norway are organised into hospital trusts (HT, "Helseforetak") within a health region. Sometimes one ICP is responsible for one hospital, and in other cases one ICP works for two or three hospitals within a hospital trust. Because of the complicated structure of the Norwegian healthcare system, it was unclear how to identify which of the 36 responders represent a hospital and which represent hospital trusts.

Because of the limited time for surveying (February 2nd 2011 to March 22nd 2011) not all techniques were used to get more responses and a higher response rate.

In the present evaluation study, we were unable to find out the proportion of hospitals that are seeking postponement due to computer problems, or deliver their reports with delay.

7. Conclusion

From 2005 to 2009, the NOIS surveillance system was effective and efficient, providing all required information. In general, the review of several important system attributes – representativeness, flexibility, stability and usefulness – resulted in a positive picture of the system.

The NOIS surveillance acts to increase awareness of infection control issues within hospitals: For many hospitals it has provided an important stimulus for initiating a review or change of clinical practice.

Despite the favorable description of most of attributes, some challenges seem to be clear: Four in ten hospitals report that the use of NOIS caused no change in clinical practice, and the hospital staff deems that their resources are too limited to prioritize training and education in NOIS activities. The system would benefit from being electronically automatized as far as possible, and the NIPH websites could be improved. The annual reports from NIPH should be published sooner after the survey periods, and hospitals could make sure to meet NIPHs deadlines for submitting their surveillance results.

7.2. Recommendations

Overall, the NOIS surveillance system appears to fulfill its purposes to a satisfactory degree.

The maintenance of NOIS' system attributes and operations is important in order to make sure that SSIs stay at the lowest possible level. As a dynamic system that is frequently revised, it is important that an evaluation is performed on a regular basis.

Recommendations

1) NIPH should provide more information on their websites and "Surveillance Days" in order to maintain communication between public

health managers and hospitals, and to share necessary educational materials on surveillance activities. NIPH can also organize work groups for ICPs, where common issues can be discussed.

2) Hospitals should ensure that all relevant hospital staff receives training and education to run NOIS. Also, hospitals should review the reporting of surveillance data to the hospital administration for improvements.

3) In their reports, NIPH should make sure that the Norwegian Ministry of Health and Care Services are informed if the necessary resources for running the NOIS surveillance system is lacking on national and local level, and help hospitals to determine the appropriate level of resources applied to surveillance activities and infection control.

4) Reporting can be simplified by implementing a complete transition to automatic input and handling of all variables in hospitals participating in NOIS. With respect to NOIS, fully digital systems in all hospitals is an obvious improvement over manual work.

5) The challenge for NIPH is now to provide more timely surveillance reports at the national and local level. Reminder emails from NIPH could make sure that hospitals submit their results by the deadline. Also, a registration service for hospitals that are seeking postponement due to computer problems or delivering their reports with delay for other reasons, can be implemented as well.

6) An external evaluation of the data quality or validation study is required.

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Appendix1. Table 1: Criteria for defining a surgical site infection (SSI)

Superficial Incisional SSI: Infection occurs within 30 days after the operation *and* infection involves only skin or subcutaneous tissue of the incision *and* at least *one* of the following:
1. Purulent drainage, with or without laboratory confirmation, from the superficial incision.
2. Organisms isolated from an aseptically obtained culture of fluid or tissue from the superficial incision.
3. At least one of the following signs or symptoms of infection: pain or tenderness, localized swelling, redness, or heat *and* superficial incision is deliberately opened by surgeon, *unless* incision is culture-negative.
4. Diagnosis of superficial incisional SSI by the surgeon or attending physician.

Deep incisional SSI: Infection occurs within 30 days after the operation if no implant† is left in place or within 1 year if implant is in place and the infection appears to be related to the operation *and* infection involves deep soft tissues (eg. fascial and muscle layers) of the incision *and* at least *one* of the following:
1. Purulent drainage from the deep incision but not from the organ/space component of the surgical site.
2. A deep incision spontaneously dehisces or is deliberately opened by a surgeon when the patient has at least one of the following signs or symptoms: fever (>38℃), localized pain, or tenderness, unless site is culture-negative.
3. An abscess or other evidence of infection involving the deep incision is found on direct examination, during reoperation, or by histopathologic or radiologic examination.
4. Diagnosis of a deep incisional SSI by a surgeon or attending physician.

Organ/space SSI: Infection occurs within 30 days after the operation if no implant† is left in place or within 1 year if implant is in place and the infection appears to be related to the operation *and* infection involves any part of the anatomy (eg. organs or spaces), other than the incision, which was opened or manipulated during an operation *and* at least *one* of the following:
1. Purulent drainage from a drain that is placed through a stab wound‡ into the organ/space.
2. Organisms isolated from an aseptically obtained culture of fluid or tissue in the organ/space.
3. An abscess or other evidence of infection involving the organ/space that is found on direct examination, during reoperation, or by histopathologic or radiologic examination.
4. Diagnosis of an organ/space SSI by a surgeon or attending physician

* Horan TC et al.
† National Nosocomial Infection Surveillance definition
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