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Major article

Surgical site infections after hip arthroplasty in Norway, 2005-2011: Influence of duration and intensity of postdischarge surveillance

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Background: Most surgical site infections (SSIs) after hip arthroplasty are detected after a patient is discharged from hospital, making postdischarge surveillance (PDS) an important component in surveillance systems. We investigated how long it was necessary to monitor hip arthroplasty patients for SSIs after hospital discharge and if passive PDS through readmissions could replace active PDS by patient questionnaire in detecting SSIs.

Methods: We used data from the Norwegian surveillance system from 2005-2011, which has active 1-year PDS, to investigate proportions of SSIs found at different time intervals after surgery and whether these SSIs could have been detected through passive PDS by investigating the proportion of patients with SSIs that were readmitted.

Results: We found that 79% of all SSIs and 82% of deep SSIs were detected after hospital discharge. 95% of deep SSIs were detected within 90 days after surgery. 14% of the deep SSIs were detected beyond 30 days after surgery, and all of these patients were readmitted because of their SSI and thus could have been detected by passive PDS.

Conclusions: Our data suggest that most deep SSIs are detected within 90 days and that passive PDS beyond 30 days after surgery may replace active PDS without reducing sensitivity.

Many countries have successfully implemented comprehensive surveillance systems for surgical site infections (SSI) in past decades. With a continuing trend toward a shorter length of hospital stay, postdischarge surveillance (PDS) is increasingly important to get a more comprehensive picture of the SSI burden.

PDS methods differ in both intensity of case finding and duration of follow-up.[1] The intensity of case finding is often described as either active or passive PDS. Active PDS is resource-demanding because the hospital must contact all patients after discharge. Passive PDS entails the hospital only getting information about SSI status among readmitted patients, and thus there is a risk of missing cases treated by other health care providers. The intensity of case-finding has varied between studies and surveillance systems and active PDS is performed in a multitude of ways. The norm for PDS duration has until now been 1 year following implant surgery and 30 days following other kinds of surgery as defined by the Centers for Disease Control and Prevention (CDC) National Healthcare Safety Network (NHSN)[2] and the European Centre for Disease Prevention and Control (ECDC).[3] From 2014 NHSN reduced the PDS duration from 1 year to 90 days after hip arthroplasty.

With the introduction of electronic health records, it is alluring to rely on data that already exist in the hospital information system.[4-7] The balance between the wish for high quality data and the resource demands of diligent PDS is the focus of this study. Using data from the Norwegian Surveillance System for Antibiotic Consumption and Healthcare-Associated Infections (NOIS), we try to answer 2 questions: For how long is it necessary to follow-up hip arthroplasty patients for SSIs after surgery? and, Can passive PDS be used in lieu of active PDS to detect SSIs?

METHODS

The NOIS SSI module was established in 2005 by regulation[8] and we have earlier reported in detail on the rationale and

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functioning of the system.[9,10] NOIS is based on the ECDC surveillance protocol[3] and the American NHSN methodology and definitions,[2,11] and is unique in that it is a mandatory system, relies heavily on automated data collection, and has active PDS. Although participation in NOIS is mandatory, the hospitals choose which procedures to report on from a prioritized list. Hip arthroplasty has third priority behind coronary artery bypass graft and cesarean section. Hospitals may submit more data than the minimum requirement of the 2 highest-priority procedures, and many do. Data are collected for September-November each year.

There are many methods with different merits for detecting and classifying SSIs that manifest after hospital discharge. PDS is generally defined as active if the hospital makes an effort to ascertain a patient's infection status independently of information that is already available in the hospital records. With passive PDS the hospital relies on in-hospital sources, such as readmission information, to detect infections after discharge. In our study we compared 1 year of active PDS by patient questionnaire confirmed by a physician, with passive PDS through readmissions as methods for detection of SSIs after hospital discharge. Patients were contacted by a questionnaire sent from the hospital 30 days after surgery and an additional questionnaire sent after 1 year. Nonresponders are sent reminders and receive telephone follow-up. SSIs for nonhospitalized patients are confirmed and classified by a physician, either the patient's general practitioner or at an outpatient clinic. A modified version of the SSI definitions is printed on the reverse side of the patient questionnaire for classification purposes. A patient's self-diagnosed infections are not included in this study. Data on SSI status are recorded at 3 postoperative intervals: discharge, 30 days, and 1 year after implant surgery.

NOIS applies the epidemiologic definitions from CDC/ECDC.[2,3] In our study we categorized SSIs as either superficial or deep (ie, includes deep incisions and organ/space involvement). Only data on deep SSIs are collected beyond 30 days. In NOIS, we additionally register whether a patient has been readmitted (with or without a reoperation) due to an SSI within 30 days and within 1 year of surgery. A readmission due to SSI is defined by the NOIS protocol as the surgical procedure under surveillance leading to an SSI that requires readmission. Whether the readmission is due to the SSI in question is determined by a physician. This provides us with the opportunity to investigate whether an SSI could have been detected solely by the patient being readmitted to hospital (ie, passive PDS).

In our study, we included data on all primary total hip arthroplasties and hemiarthroplasties of the hip as defined by the Nordic Medico-Statistical Committee's Classification of Surgical Procedures[12] from hospitals that have submitted 1-year follow-up data to NOIS for the years 2005-2011. We calculated SSI rates and the proportion of SSIs detected before and after hospital discharge and at different postoperative time intervals. We also calculated sensitivity with 95% confidence intervals (CIs) (adjusted Wald) with active and passive PDS at different postoperative time intervals. By SSI rate we mean the cumulative proportion of patients who develop an SSI within a given time interval after surgery. Sensitivity was estimated by dividing SSIs detected using different PDS strategies by SSIs detected with active PDS for 1 year by patient questionnaire. Only deep SSIs are included when calculating sensitivity because superficial SSIs are not included beyond 30 days.

The NOIS regulations govern the collection, collation, storage, and use of data; the submission of data to the Norwegian Institute of Public Health; as well as the responsibilities and duties of the hospital trusts and various authorities. Because NOIS is a national health register governed by a separate act, patient consent is not required.[8]

RESULTS

The NOIS national database includes 12,928 primary hip arthroplasties from 54 hospitals for the years 2005-2011. We included data from the 29 hospitals that submitted 1-year follow-up data. Twenty-eight hospitals submitted data on total hip arthroplasties and 22 submitted data on hemiarthroplasties of the hip. We excluded 10 nonclassifiable records, leaving 6,528 hip arthroplasties, 4,893 total hip arthroplasties, and 1,635 hemiarthroplasties of the hip. Follow-up was complete for 96% of patients at 30 days and 87% at 1 year according to our definition.[9] SSIs were identified in 233 patients, for whom 15 had missing infection dates. Of 15 SSIs with missing infection dates—12 superficial and 3 deep—were detected after hospital discharge and were reported at the 30-day follow-up. Of 218 SSIs with valid infection dates 131 (60%) were deep, and 113 (86%) of these were detected within 30 days of surgery and 18 (14%) between 31 days and 1 year.

Figure 1 shows the number and percentage of superficial and deep SSIs detected at different postoperative time intervals for total hip arthroplasties and hemiarthroplasties of the hip. The SSIs following total hip arthroplasty peak earlier than following hemiarthroplasty of the hip. Ninety-two percent of all SSIs were detected within 30 days and 95% were detected within 90 days after surgery. The proportion of deep SSIs is larger for hemiarthroplasty of the hip (73%) than for total hip arthroplasty (46%). The median time to infection was 16 days for all SSIs, and 17 days for deep SSIs. The median postoperative length of stay was 6 days for total hip arthroplasty and 7 for hemiarthroplasty of the hip. We observed a reduction in the median postoperative length of stay from 7 (2005-2008) to 5 (2009-2011) days for total hip arthroplasty and from 8-6 days for hemiarthroplasty of the hip.

Table 1 shows the number of SSIs and the SSI rate during inpatient stay and after discharge and the number and percent of the SSIs detected by passive PDS (ie, because of readmission). The overall SSI rate was 3.6%. The rate was higher among hemiarthroplasties of the hip than total hip arthroplasties for deep SSIs. Seventy-nine percent of all SSIs were detected after hospital discharge, and 82% of the deep SSIs were detected after discharge. The proportion of deep SSIs detected after discharge increased from 79% in 2005-2008 to 85% in 2009-2011. Ninety-four (85%) of the deep and 9 (12%) of the superficial SSIs after hospital discharge could have been detected by passive PDS. The SSI rate for deep SSIs that could have been detected with passive PDS was 1.0% for total hip arthroplasties and 2.8% for hemiarthroplasties of the hip.

Table 2 shows the SSI rates and sensitivity of different case finding strategies for deep SSIs compared with active PDS by patient questionnaire for 1 year. The sensitivity varies from 0.18 by inpatient surveillance only to 1.00 by a combination of active and passive PDS. The sensitivity of passive PDS for 1 year is 0.85 compared with active PDS for 1 year. Of the SSIs that were detected within 30 days of surgery, 94 (83%) were readmitted due to SSI and could have been detected by passive PDS. All 18 deep SSIs that were detected between 31 days and 1 year were readmitted, 11 of these within 90 days. In total, 124 (95%) of the deep SSIs were detected within 90 days of surgery.

DISCUSSION

In our study of SSIs after primary hip arthroplasty in Norway, we found that 79% of all SSIs and 82% of deep SSIs were detected after hospital discharge. Almost all SSIs were detected within 90 days after surgery. Only 14% of the deep SSIs were detected beyond 30 days, and all of these patients were readmitted because of their SSI and thus could have been detected by passive PDS. Active PDS for the first 30 days and passive PDS thereafter achieved the same

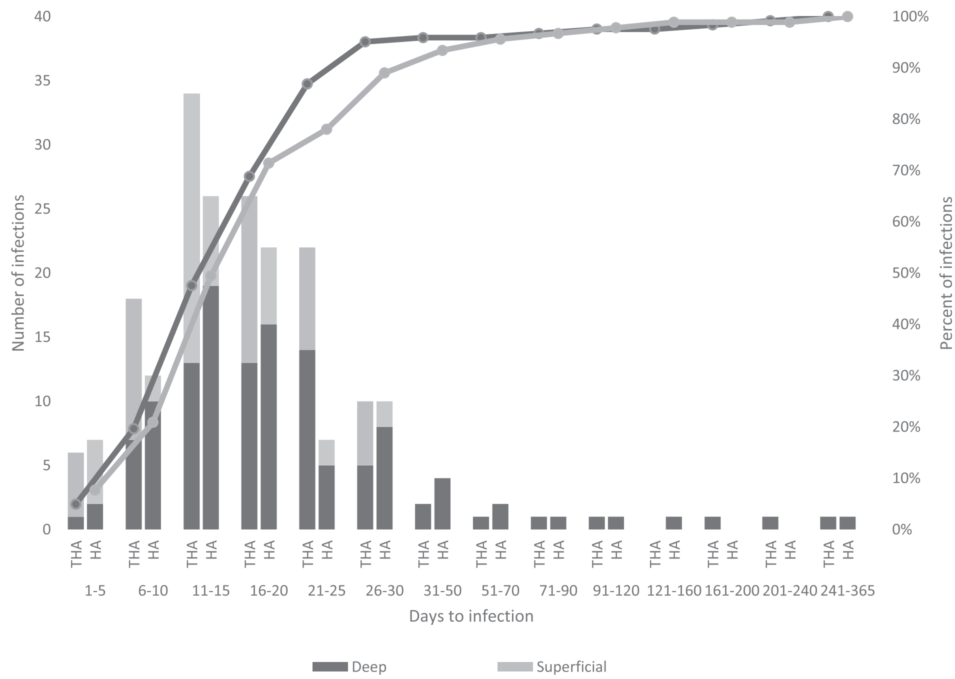

Fig 1. Number of days to surgical site infection and percent of infections detected at different points in time after total hip arthroplasty (THA) and hemiarthroplasty (HA) by infection type, based on data from the Norwegian Surveillance System for Antibiotic Consumption and Healthcare-Associated Infections 2005-2011. Infections with missing infection date were excluded.

Table 1
Number and rate of surgical site infections (SSIs)* detected during inpatient stay and after hospital discharge and percent of SSIs detected by passive postdischarge surveillance (readmissions) by type of procedure, based on data from the Norwegian Surveillance System for Antibiotic Consumption and Healthcare-Associated Infections 2005-2011

	Total hip arthroplasty			Hemiarthroplasty			Total		
	No. of SSIs	SSI rate (%)	Readmitted (%)	No. of SSIs	SSI rate (%)	Readmitted (%)	No. of SSIs	SSI rate (%)	Readmitted (%)
During inpatient stay									
Superficial	17	0.3		8	0.5		25	0.4	
Deep	6	0.1		18	1.1		24	0.4	
All	23	0.5		26	1.6		49	0.8	
After discharge									
Superficial	56	1.1	6 (11)	18	1.1	3 (17)	74	1.1	9 (12)
Deep	57	1.2	48 (84)	53	3.2	46 (87)	110	1.7	94 (85)
All	113	2.3	54 (48)	71	4.3	49 (69)	184	2.8	103 (56)
Total	136	2.8		97	5.9		233	3.6	

*SSIs with missing infection date included.

sensitivity as active 1-year PDS by patient questionnaire for deep SSIs.

The methodologies for PDS vary greatly in studies that address SSIs after hip arthroplasty.[13] We have summarized some relevant studies in Table 3. One study used data from the German surveillance system combined with active PDS by patient questionnaire 1 year after hip arthroplasty.[14] They found that all SSIs that were detected by patient questionnaire after discharge had been in contact with an outpatient clinic, and could have been detected without active PDS.

The Dutch surveillance system has several types of PDS for 1 year following hip arthroplasty.[15] With their recommended active PDS method, which requires that almost all patients return for an evaluation by the surgeon, they found SSI rates similar to ours for both total hip arthroplasty and hemiarthroplasty of the hip, although the proportion of SSIs detected after hospital discharge were different from our findings. With passive PDS the differences between our findings were larger.

The Finnish surveillance system has 1-year active PDS after hip and knee arthroplasty with several different follow-up methods.[16] They have follow-up visits at a hospital at 2 months and 1 year. They also systematically identify SSIs upon readmission and conduct follow-up patient contact with the health care system by questionnaire. Their SSI rates and proportion of SSIs detected after discharge correspond well with our results.

One US study[17] compared different methods of utilizing automated data to detect SSIs in hospitals before and after hospital discharge (ie, passive PDS). They found diagnosis-based electronic screening of index stay and readmissions more sensitive than traditional surveillance in detecting deep SSIs. They found an adjusted overall SSI rate of 1.3% and 90% of total hip arthroplasty SSIs after discharge (during subsequent hospitalization) using a combination of computer algorithms. They also ascertained that nearly all SSIs were detected within 70 days after surgery.

A study by the CDC,[18] with predominantly passive PDS, found that 24% of the deep SSIs following total hip arthroplasty were detected beyond 30 days after surgery. None were detected beyond 90 days. The CDC study reports an SSI rate of 1.2%, which is similar to our findings for passive PDS.

Table 2
Deep surgical site infection (SSI)* rates and sensitivity of case-finding using different surveillance durations and intensities, based on data from the Norwegian Surveillance System for Antibiotic Consumption and Healthcare-Associated Infections 2005-2011

	Total hip arthroplasty			Hemiarthroplasty			Total		
Surveillance method	Deep SSIs	SSI rate (%)	Sensitivity (95% confidence interval)	Deep SSIs	SSI rate (%)	Sensitivity (95% confidence interval)	Deep SSIs	SSI rate (%)	Sensitivity (95% confidence interval)
Active PDS for 1 y	61	1.2	Ref	70	4.3	Ref	131	2.0	Ref
Active PDS for 90 d	57	1.2	0.93 (0.84-0.98)	67	4.1	0.96 (0.88-0.99)	124	1.9	0.95 (0.89-0.98)
Active PDS for 30 d	53	1.1	0.87 (0.76-0.93)	60	3.7	0.86 (0.75-0.92)	113	1.7	0.86 (0.79-0.91)
Active for 30 d and passive to 1 y	61	1.2	1.00 (0.93-1.00)	70	4.3	1.00 (0.94-1.00)	131	2.0	1.00 (0.97-1.00)
Active for 30 d and passive to 90 d	57	1.2	0.93 (0.84-0.98)	67	4.1	0.96 (0.88-0.99)	124	1.9	0.95 (0.89-0.98)
Passive PDS for 1 y	52	1.1	0.85 (0.74-0.92)	60	3.7	0.86 (0.75-0.92)	112	1.7	0.85 (0.78-0.91)
Passive PDS for 90 d	48	1.0	0.79 (0.67-0.87)	57	3.5	0.81 (0.71-0.89)	105	1.6	0.80 (0.72-0.86)
Passive PDS for 30 d	44	0.9	0.72 (0.60-0.82)	50	3.1	0.71 (0.60-0.81)	94	1.4	0.72 (0.63-0.79)
Inpatient only	6	0.1	0.10 (0.04-0.20)	18	1.1	0.26 (0.17-0.37)	24	0.4	0.18 (0.13-0.26)

PDS, postdischarge surveillance; *Ref*, reference category.
*SSIs with missing infection date excluded.

Table 3
Summary and characteristics of comparable studies

Study	Data collection years	Included procedures	PDS methods	Proportion of deep SSIs detected after discharge	SSI rate deep	Proportion of all SSIs detected after discharge	SSI rate all
Germany							
Huenger, 2005[14]	2000-2001	THA and HA	Active	33%*	2.4%	25%	3.15%
Netherlands							
Mannien, 2006[15]	1996-2004	THA and HA	Active	51%*	1.2%*	39%*	3.1%*
			Passive	47%*	1.1%*	21%*	3.2%*
Finland							
Huotari, 2006[16]	1999-2002	THA, HA and knee arthroplasty	Active and passive combined	82%*	0.9%	56%*	3.3%
USA							
Bolon, 2009[17]	2002-2004	THA	Passive	N/A	N/A	90%	1.3%
USA							
Lankiewicz, 2012[18]	2007	THA	Passive	N/A	1.2%*	N/A	N/A
USA							
Yokoe, 2013[19]	2006-2009	THA	Passive	N/A	N/A	85%	2.3%
Our study	2005-2011	THA and HA	Active	82%	2.0%	79%	3.6%
			passive	70%	1.7%	44%	1.9%

HA, hemiarthroplasties of the hip; *N/A*, not available; *PDS*, postdischarge surveillance; *SSI*, surgical site infection; *THA*, total hip arthroplasty.
*Estimated from numbers given in the article.

Another recent US study by Yokoe et al[19] used ICD-9-CM diagnosis codes to detect SSIs after total hip arthroplasty. They found 85% of the infections after discharge when they included SSIs that were detected upon readmission to other hospitals than the index hospital. They also found that 60% of SSIs were detected within 30 days and 81% within 90 days. Although we classified the study by Yokoe et al[19] as passive PDS, it bridges the gap between active and passive PDS methods by electronically capturing SSIs that are detected at other hospitals. The final step in erasing the distinction between active and passive PDS would be to collect data electronically from ambulatory care settings, such as data from physicians' offices. If it is possible to use high quality data from such other sources, traditional forms of active PDS may become redundant.

These studies all address PDS up to 1 year after surgery. Although they present data in different ways, use different methodology, represent different time periods and cultures, and have different PDS intensity, all point in the same direction as our study. In Norway, mean length of stay has decreased in the past few decades from about 8 days in 1990 to about 4 days in 2010 for all hospitalizations.[20] In a Dutch study[15] the authors found that the median length of stay for total hip arthroplasty decreased from 13 days (1996-1999) to 10 days (2000-2003) and correspondingly the proportion of SSIs detected after discharge increased from 23%-44%. Our study indicates the same tendency. Because of decreasing length of stay, older studies may find a larger proportion of the infections before discharge. This is shown in the comparison in Table 3, where the older studies show a smaller proportion of the SSIs detected after hospital discharge than the more recent studies. In line with the results from these studies, we observe that most deep SSIs could have been detected through passive PDS. Considering the small proportion of SSIs detected beyond 30 days versus the cost to infection control staff and hospitals in performing active PDS by patient questionnaire, we question whether this type of active 1-year PDS is necessary.

PDS intensity is closely related to the increasing availability and quality of electronic surveillance systems. Active PDS by patient questionnaire is labor intensive and passive PDS has been associated with sacrificing sensitivity.[17,21] Concern has also been raised with regard to surveillance fatigue that may result in less diligent case-finding by traditional methods over time,[22] and more so with the additional burden of active 1-year PDS. Advances in data mining, data linkage, and electronic surveillance systems have blurred the distinction between active and passive PDS in that postdischarge patient information is more easily obtainable than previously. Thus passive PDS may become more sensitive in the future.[7,19,23-25] Another effect of electronic surveillance is the opportunity to gather more standardized PDS data.[26] Passive PDS through electronic monitoring of readmissions may give more comparable and uniform data than active PDS, which is more dependent on health care personnel enthusiasm. Regardless of degree of automation and data sources, passive PDS requires high quality systems for data harvesting and good and uniform coding practices by health care personnel.[27]

In our study, all 18 cases of deep SSIs detected beyond 30 days with active PDS by patient questionnaire were readmitted, and in most cases underwent reoperation. This means that they could have been detected by passive PDS and that the 1-year questionnaire was redundant. The burden on hospital staff of follow-up by patient questionnaire after both 30 days and 1 year is a major concern. Many hospitals find 1-year active PDS after hip arthroplasty difficult, because many of the patients have died, have been admitted to nursing homes, or have dementia. Despite being mandatory, compliance with reporting 1-year hip arthroplasty PDS data was poor and only about half of the hospitals completed 1-year follow-up and submitted data to the national registry. However, discontinuing all PDS beyond 30 days would not be in line with ECDC and CDC definitions, and is therefore not considered an option. We also have to take into account that there is an interest among orthopedic surgeons in SSIs that develop late because these are serious infections that require revision surgery.[28,29] The motivation to continue PDS beyond 30 days is therefore present in many Norwegian hospitals.

Relying more on passive PDS is an appealing option in Norway, especially because most hospitals already have electronic surveillance systems in place. This would require adaptation of the electronic surveillance systems with suitable algorithms, which can be costly and complex to develop. Discontinuing the patient questionnaires would remove the possibility of detecting patients with SSIs who are admitted to other hospitals in addition to those who receive care in the ambulatory setting. In the United States,[19] researchers found that 17% of the SSIs would be missed by limiting PDS to the index hospital. It is difficult to estimate what this would imply in Norway, but because of the geography, national funding of most hospitals, and the hospital structure it may be reasonable to assume that a large proportion of patients would be readmitted to the index hospital.

Most countries in Europe and worldwide do not have computer systems for SSI surveillance. We believe that the main finding of this study—that active PDS is not necessary beyond 30 days—is still applicable to other countries. Many countries already have, or are in the process of implementing, electronic medical records. This creates an opportunity for harnessing already existing data for surveillance purposes. Only data on deep SSIs are collected beyond 30 days, and the probability of these patients returning to a hospital is greater than for superficial SSIs. Requesting computer printouts of readmissions for manual review should be possible from most hospital computer systems.

There are several limitations to this study. The study only includes hip arthroplasty and results may therefore not apply to other types of surgery. The numbers are small and the study is restricted to hospitals that have completed 1-year PDS (about half of all Norwegian hospitals), and may not be representative of all hospitals in Norway. Active PDS in the form of patient questionnaires as defined by NOIS may not be the optimal way of detecting SSIs after hospital discharge. Some of the reasons why all the late SSIs were coded as readmitted in NOIS may be due to health care personnel manually checking for readmissions after a patient has returned a questionnaire with an SSI indication. They may not have been detected by passive PDS alone if the hospital electronic health records are not adequately coded and harvested or if the patient is readmitted to another hospital.

CONCLUSIONS

PDS of surgical site infections has become more important with shorter lengths of hospital stay. We found that 95% of deep SSIs were detected within 90 days of surgery. All deep infections beyond 30 days could have been detected by passive PDS, indicating that passive surveillance beyond 30 days may replace active surveillance without reducing sensitivity in case findings.

References

1. Gastmeier P. Postdischarge surveillance for surgical site infection: the continuing challenge. Infect Control Hosp Epidemiol 2006;27:1287-90.
2. Horan TC, Gaynes RP, Martone WJ, Jarvis WR, Emori TG. CDC definitions of nosocomial surgical site infections, 1992: a modification of CDC definitions of surgical wound infections. Infect Control Hosp Epidemiol 1992; 13:606-8.
3. ECDC. Surveillance of surgical site infections in European hospitals– HAISSI protocol. Version 102. Stockholm: European Centre for Disease Prevention and Control; 2012.
4. Goto M, Ohl ME, Schweizer ML, Perencevich EN. Accuracy of Administrative code data for the surveillance of healthcare-associated infections: a systematic review and Meta-Analysis. Clin Infect Dis 2014;58:688-96.
5. van Mourik MS, Troelstra A, van Solinge WW, Moons KG, Bonten MJ. Automated surveillance for healthcare-associated infections: opportunities for improvement. Clin Infect Dis 2013;57:85-93.
6. Leal J, Laupland KB. Validity of electronic surveillance systems: a systematic review. J Hosp Infect 2008;69:220-9.
7. Freeman R, Moore LS, Garcia Alvarez L, Charlett A, Holmes A. Advances in electronic surveillance for healthcare-associated infections in the 21st Century: a systematic review. J Hosp Infect 2013;84:106-19.
8. Ministry of Health and Care Services, Oslo. Norwegian Surveillance System for Antibiotic Consumption and Healthcare-Associated Infections (NOIS) Act 2005 Available from: http://lovdata.no/cgi-wift/wiftldles?doc=/usr/www/lovdata/for/sf/ho/ho-20050617-0611.html&emne=nois*&&. Accessed January 21, 2015.
9. Løwer HL, Eriksen H-M, Aavitsland P, Skjeldestad FE. Methodology of the Norwegian Surveillance System for Healthcare-Associated Infections: the value of a mandatory system, automated data collection, and active postdischarge surveillance. Am J Infect Control 2013;41:591-6.
10. Dale H, Skramm I, Lower HL, Eriksen HM, Espehaug B, Furnes O, et al. Infection after primary hip arthroplasty: a comparison of 3 Norwegian health registers. Acta Orthop 2011;82:646-54.
11. Emori TG, Culver DH, Horan TC, Jarvis WR, White JW, Olson DR, et al. National nosocomial infections surveillance system (NNIS): description of surveillance methods. Am J Infect Control 1991;19:19-35.
12. The NOMESCO. Classification of Surgical Procedures [Internet]. Nordic Centre for Classifications in Health Care. 2009. Available from: http://nowbase.org/~/media/Projekt%20sites/Nowbase/Publikationer/NCSP/NCSP%201_16.ashx; 2009. Accessed January 21, 2015.
13. Urquhart DM, Hanna FS, Brennan SL, Wluka AE, Leder K, Cameron PA, et al. Incidence and risk factors for deep surgical site infection after primary total hip arthroplasty: a systematic review. J Arthroplasty 2010;25:1216-1222. e1-3.
14. Huenger F, Schmachtenberg A, Haefner H, Zolldann D, Nowicki K, Wirtz DC, et al. Evaluation of postdischarge surveillance of surgical site infections after total hip and knee arthroplasty. Am J Infect Control 2005; 33:455-62.
15. Mannien J, Wille JC, Snoeren RL, van den Hof S. Impact of postdischarge surveillance on surgical site infection rates for several surgical procedures: results from the nosocomial surveillance network in The Netherlands. Infect Control Hosp Epidemiol 2006;27:809-16.
16. Huotari K, Lyytikainen O, Hospital Infection Surveillance Team. Impact of postdischarge surveillance on the rate of surgical site infection after orthopedic surgery. Infect Control Hosp Epidemiol 2006;27:1324-9.
17. Bolon MK, Hooper D, Stevenson KB, Greenbaum M, Olsen MA, Herwaldt L, et al. Improved surveillance for surgical site infections after orthopedic implantation procedures: extending applications for automated data. Clin Infect Dis 2009; 48:1223-9.
18. Lankiewicz JD, Yokoe DS, Olsen MA, Onufrak F, Fraser VJ, Stevenson K, et al. Beyond 30 days: does limiting the duration of surgical site infection follow-up limit detection? Infect Control Hosp Epidemiol 2012;33:202-4.
19. Yokoe DS, Avery TR, Platt R, Huang SS. Reporting surgical site infections following total hip and knee arthroplasty: impact of limiting surveillance to the operative hospital. Clin Infect Dis 2013;57:1282-8.
20. SAMDATA Spesialisthelsetjenesten 2012. Oslo, Norway: The Norwegian Directorate of Health, 2012 978-82-8081-287-2. Available from: http://helsedirektoratet.no/publikasjoner/samdata-2012/Sider/default.aspx. Accessed January 21, 2015.
21. Manian FA, Meyer L. Adjunctive use of monthly physician questionnaires for surveillance of surgical site infections after hospital discharge and in ambulatory surgical patients: report of a seven-year experience. Am J Infect Control 1997;25:390-4.
22. Trick WE. Decision making during healthcare-associated infection surveillance: a rationale for automation. Clin Infect Dis 2013;57:434-40.

23. FitzHenry F, Murff HJ, Matheny ME, Gentry N, Fielstein EM, Brown SH, et al. Exploring the frontier of electronic health record surveillance: the case of postoperative complications. Med Care 2013;51:509-16.
24. Calderwood MS, Ma A, Khan YM, Olsen MA, Bratzler DW, Yokoe DS, et al. Use of Medicare diagnosis and procedure codes to improve detection of surgical site infections following hip arthroplasty, knee arthroplasty, and vascular surgery. Infect Control Hosp Epidemiol 2012;33:40-9.
25. Inacio MC, Paxton EW, Chen Y, Harris J, Eck E, Barnes S, et al. Leveraging electronic medical records for surveillance of surgical site infection in a total joint replacement population. Infect Control Hosp Epidemiol 2011;32:351-9.
26. Klompas M, Yokoe DS. Automated surveillance of health care-associated infections. Clin Infect Dis 2009;48:1268-75.
27. Leaper D, Tanner J, Kiernan M. Surveillance of surgical site infection: more accurate definitions and intensive recording needed. J Hosp Infect 2013;83:83-6.
28. Phillips JE, Crane TP, Noy M, Elliott TS, Grimer RJ. The incidence of deep prosthetic infections in a specialist orthopaedic hospital: a 15-year prospective survey. J Bone Joint Surg Br 2006;88:943-8.
29. Ong KL, Kurtz SM, Lau E, Bozic KJ, Berry DJ, Parvizi J. Prosthetic joint infection risk after total hip arthroplasty in the Medicare population. J Arthroplasty 2009;24(6 Suppl):105-9.