

1 INTRODUCTION

Surgical site infections (SSIs) were the third most common type of healthcare-associated infections (HAI) in the second national HAI one-day prevalence survey (1). It was conducted in all Slovenian acute care hospitals within the European point prevalence survey of HAI and antimicrobial use (2). SSIs are associated with longer post-operative hospital stays, additional surgical procedures, treatment in intensive care units and higher mortality (3). Surveillance of SSIs contributes towards lowering their incidence rates and to monitoring the quality of healthcare (4, 5).

Surveillance of HAI is mandatory according to the Slovenian Communicable Diseases Act (Official Gazette of the Republic of Slovenia number 33/06) and has been recommended by the Council Recommendation of 9 June 2009 on patient safety, including the prevention and control of HAI (2009/C 151/01). The Slovenian National HAI surveillance (HAI-Sur) system is being developed by the National Institute of Public Health (in Slovene: Nacionalni inštitut za javno zdravje - NIJZ) in collaboration with acute care hospitals that cooperate in the HAI-Sur network (6). SSIs surveillance (SSI-Sur) one of the HAI surveillance modalities has been implemented by the SSI-Sur network, sub-network of the HAI-Sur network.

The objective of this paper is to present the results of SSIs surveillance in Slovenian acute care hospitals for the period from 2013 to 2016 and compare them to the reference data for European Union (EU) and European Economic Area (EEA) countries published by the European Centre for Disease Prevention and Control (ECDC) (7). The aim is to contribute to evidence-based SSIs prevention and control in Slovenian acute care hospitals.

2 METHODS

2.1 Data Collection

Between 2013 and 2016 surveillance of SSIs in voluntarily participating Slovenian acute care hospitals was conducted according to the Slovenian SSI-Sur protocol (version 1.0), which was consistent with the ECDC protocol for SSIs surveillance (version 1.02) (8, 9). In brief, the surgical procedures under surveillance were caesarean section, cholecystectomy, colon surgery, hip prosthesis and knee prosthesis. The shortest surveillance period during which all patients with the selected surgical procedure under surveillance in a participating hospital were enrolled, was three months (a quarter of a year). Data collected for all patients included their age, date of admission, date of surgery, whether the operation was urgent, whether the patient received antibiotic prophylaxis within two hours before the incision (or during surgery for caesarean section) and date of discharge. Furthermore, data for the

estimation of the US National Healthcare Safety Network (NHSN) risk index (basic SSI risk index according to the ECDC SSI surveillance protocol), which is based on the presence of three major risk factors (duration of the operation, wound contamination class and the American Society of Anaesthesiologists (ASA) physical status classification), was collected (9-11). SSIs cases were ascertained and classified according to the 2012 EU case definitions (12). Only information about SSIs detected within 30 days after surgery were recorded, except for SSIs following orthopaedic operations with an implant in place (hip and knee prostheses), where SSIs up to one-year after surgery were recorded (7, 8). The SSIs data collected included the date of onset, type of SSI according to the EU case definitions (superficial, deep or organ/space) and, if available, information on microorganisms identified in SSI.

2.2 Data Management and Analysis

Data was entered by hospital staff using a data entry programme Epi Info (Epi Info, version 7, CDC, Atlanta, GA, USA) prepared by the NIJZ with built-in code range and filter checks. After each data collection period, the participating hospitals sent their quarterly SSI-Sur data sets to the NIJZ.

We performed descriptive analyses using the national SSI-Sur data set from 2013 to 2016, using the statistical software SPSS (Statistical Package for the Social Sciences, version 21.0, Chicago, IL, USA). We described characteristics of patients, surgical procedures, SSIs, microorganisms identified, and patients' length of hospital stay. For continuous variables such as age or duration of the operation we calculated the mean, median and inter-quartile range (IQR), the range between 25th percentile (P25) and 75th percentile (P75). We calculated three main indicators for each surgical procedure: (a) cumulative SSIs incidence (the percentage of SSIs diagnosed during hospital stay and after discharge (detected at hospital readmission or by post-discharge surveillance) per 100 operations); (b) cumulative in-hospital SSIs incidence (the percentage of SSIs diagnosed during hospital stay per 100 operations); and (c) in-hospital SSIs incidence density (number of in-hospital SSIs per 1 000 post-operative patient-days). The latter indicator only includes SSI diagnosed during hospital stay in patients with a known discharge date from hospital. We used the Clopper-Pearson exact method for calculating the 95% confidence intervals. As most Slovenian SSIs surveillance data were collected from 2013 to 2014, we compared our results with the reference data for EU/EEA countries for the same period (from 2013 to 2014) published by ECDC, although the data cannot be considered fully representative for all surgical wards in EU/EEA acute care hospitals (7).

2.3 Legal Basis and Ethics

Surveillance of SSIs was conducted according to the Slovenian Communicable Diseases Act (Official Gazette of the Republic of Slovenia number 33/06) within the Slovenian SSI-Sur network of voluntarily participating acute care hospitals. Only personnel in participating hospitals knew the identity of all patients enrolled into SSIs surveillance and treated this data confidentially. The data submitted to NIJZ did not contain information on the identity of patients.

Before the start of data collection, NIJZ obtained ethical consent to the data collection within the Slovenian National HAI-Sur system, which includes the SSI-Sur system from the Medical Ethical Committee of the Republic of Slovenia at the Ministry of Health (Consent number: 68/04/08).

3 RESULTS

3.1 Participating Hospitals

SSIs surveillance data for selected surgical procedures for different quarters from 2013 to 2016 were reported to NIJZ by seven hospitals: General hospital (GH) Brežice, GH Celje, GH Jesenice, GH Slovenj Gradec, GH Trbovlje, University Medical Centre (UMC) Ljubljana and UMC Maribor.

3.2 Surgical Procedures under Surveillance

We collected data from 1080 patients. The highest proportion of patients enrolled in the SSIs surveillance were patients with cholecystectomy (57.4%), followed by patients with caesarean section (29.0%), hip prosthesis (4.7%), knee prosthesis (4.5%) and colon surgery (4.4%). Item response rates for all individual variables in the SSI-Sur data set for 2013-2016 were above 95%.

3.2.1 Caesarean Section

Information about 313 caesarean section operations from April 2013 to December 2013 was submitted to NIJZ by four hospitals. The mean age of patients was 31 years (median: 31 years; IQR: 27-34 years). One percent of patients had ASA score ≥ 3 , corresponding to a severe systemic disease or worse. A total of 55.9% of operations were urgent (inter-hospital range: 50.0%-66.0%). There were no contaminated or dirty wounds. 91.4% of patients received antibiotic prophylaxis during surgery (inter-hospital range: 82.4%-97.9%). The mean duration of an operation was 38 minutes (median: 35 minutes; IQR: 30-45 minutes). The median length of post-operative stay was five days (inter-hospital range: four to six days).

A total of 14 SSIs were reported within 30 days of the operation. Six SSIs were detected before discharge. Two

hospitals conducted post-discharge surveillance. Among 14 SSIs, eight were superficial incisional SSI, three were deep incisional SSIs, two were organ/space SSIs and one was of unknown type.

The estimated pooled cumulative SSIs incidence was 4.5% (95% CI: 2.5%-7.4%; inter-hospital range: 0.0%-13.8%). The estimated pooled cumulative in-hospital SSIs incidence was 1.9% (95% CI: 0.7%-4.1%; inter-hospital range: 0.0%-6.4%). Pooled in-hospital SSIs incidence density was 3.7 (95% CI: 1.4-8.1) per 1000 post-operative patient-days (inter-hospital range: 0.0-11.5 SSI per 1000 post-operative patient-days).

Microbiological data was available for one SSI. A coagulase-negative staphylococcus was isolated.

3.2.2 Cholecystectomy

Information about 620 cholecystectomies from April 2013 to December 2016 was submitted by three hospitals. The mean age of patients was 54 years (median: 55 years; IQR: 40-65 years). 13.2% of patients had an ASA score ≥ 3 . 18.7% of operations were urgent (inter-hospital range: 2.6%-26.6%). There were 3.4% of contaminated or dirty wounds (inter-hospital range: 0.0%-8.8%). 27.3% of patients received antibiotic prophylaxis before surgery (inter-hospital range: 3.9%-37.6%). The mean duration of operation was 59 minutes (median: 52 minutes; IQR: 40-71 minutes). The median length of post-operative stay was two days (inter-hospital range: one to four days).

A total of 36 SSIs were detected within 30 days of the operation. All three hospitals conducted post-discharge surveillance. Twelve SSIs were detected before discharge. Among 36 SSIs, 20 were superficial incisional SSIs, nine were deep incisional SSIs, six were organ/space SSIs and one was of unknown type.

The estimated pooled cumulative SSIs incidence was 5.8% (95% CI: 4.1%-7.9%; inter-hospital range: 3.3%-22.1%). The estimated pooled cumulative in-hospital SSIs incidence was 1.9% (95% CI: 1.0%-3.4%; inter-hospital range: 1.0%-4.1%). Pooled in-hospital SSIs incidence density was 6.8 (95% CI: 3.5-11.9) per 1000 post-operative patient-days (inter-hospital range: 4.1-11.9 SSI per 1000 post-operative patient-days). The annually estimated in-hospital SSIs incidence density in the only hospital that conducted SSIs surveillance for three consecutive years, the point estimates dropped from 9.8 SSIs per 1000 post-operative patient-days in 2014 to 2.8 SSIs per 1000 post-operative patient-days in 2016.

Microbiological data was available for six SSIs. For four SSIs one microorganism was identified (*Escherichia coli* (two SSIs), *Staphylococcus aureus* and *Pseudomonas aeruginosa*).

3.2.3 Colon Surgery

Information about 47 colon surgeries from July 2013 to June 2014 was submitted by one hospital. The mean age of patients was 72 years (median: 75 years; IQR: 63-80 years). 36.2% of patients had ASA score ≥ 3 . 21.3% of operations were urgent. 14.9% of wounds were contaminated or dirty. 97.9% of patients received antibiotic prophylaxis before surgery. The mean duration of operation was 136 minutes (median: 125 minutes; IQR: 104-166 minutes). The median length of post-operative stay was seven days. A total of 11 SSIs were detected before discharge and two after discharge. Among the 13 SSIs, three were superficial incisional SSIs, seven were deep incisional SSIs and three were organ/space SSIs.

Estimated cumulative SSIs incidence was 27.7% (95% CI: 15.6%-42.6%). The estimated cumulative SSIs in-hospital incidence was 24.4% (95% CI: 12.9%-39.5%). In-hospital SSIs incidence density was 24.8 (95% CI: 12.5-44.0) per 1000 post-operative patient-days.

Microbiological data was available for eight SSIs. For two SSIs one microorganism was identified (*Escherichia coli* and *Streptococcus haemolyticus*).

3.2.4 Hip Prosthesis

Information about 51 hip prostheses from October 2013 to February 2014 was submitted by one hospital. The mean age of patients was 67 years (median: 71 years; IQR: 58-78 years). 43.1% of patients had ASA score ≥ 3 . There were no urgent operations and no contaminated or dirty wounds. 94.1% of patients received antibiotic prophylaxis before surgery. The mean duration of operation was 81 minutes (median: 70 minutes; IQR: 55-90 minutes). The median length of post-operative stay was six days.

Two SSIs were reported within a year of the operation, one was detected before and one after discharge. Among two SSIs, one was organ/space SSI and for the other there was no information about SSI type.

The estimated cumulative SSIs incidence was 3.9% (95% CI: 0.5%-13.5%). The estimated cumulative in-hospital SSIs incidence was 2.0% (95% CI: 0.0%-10.4%). In hospital SSIs incidence density was 2.6 (95% CI: 0.1-14.2) per 1000 post-operative patient-days.

Microbiological data was available for both SSIs and from both more than one microorganism was isolated.

3.2.5 Knee Prosthesis

Information about 49 knee prostheses from October 2013 to February 2014 was submitted by one hospital. The mean age of patients was 69 years (median: 72 years; IQR: 63-76 years). 57.1% of patients had ASA score ≥ 3 . There were no urgent operations and no contaminated or dirty wounds. 89.8% of patients received antibiotic prophylaxis before surgery. The mean duration of operation was 76 minutes (median: 75 minutes; IQR: 68-84 minutes). The median length of post-operative stay was six days. The hospital conducted post-discharge surveillance.

No SSIs were reported.

3.3 Comparison of Slovenian SSI Surveillance Results to the EU/EEA Reference Data

Table 1 shows pooled patient and operation related characteristics, pooled SSIs cumulative incidence and SSIs incidence density by surgical category for all participating Slovenian acute care hospitals and all surveillance periods from 2013 to 2016 and respective reference data for the EU/EEA countries for the period from 2013 to 2014 published by ECDC (7).

4 DISCUSSION

These are the first results of the Slovenian National SSIs surveillance system. As expected, the estimated SSIs incidence rates varied between different surgical categories and between different participating hospitals. Since we used standardised European SSIs surveillance methodology, our results can be compared to the reference SSIs surveillance data for EU/EEA countries published by ECDC (7). These comparisons suggest that the estimated SSIs incidence rates for some surgical procedures under surveillance in some participating hospitals were rather high.

Among the three different SSIs incidence indicators estimates for different surgical categories in different Slovenian acute care hospitals in different surveillance periods, the incidence density of in hospital SSIs is most suitable for comparisons between hospitals and between countries. This indicator includes only SSIs diagnosed during hospital stay and does not depend on whether hospitals conduct post-discharge surveillance. It is adjusted for differences in post-operative hospital stay between hospitals.

Table 1. Patient and operation related characteristics, surgical site infections (SSIs) cumulative incidence and SSIs incidence density by surgical category: Slovenian SSIs surveillance results (2013-2016) and EU/EEA SSIs surveillance results (2013-2014).

	Caesarean section		Cholecystectomy		Colon surgery		Hip prosthesis		Knee prosthesis	
	Slovenia	EU/EEA ^a	Slovenia	EU/EEA ^a	Slovenia	EU/EEA ^a	Slovenia	EU/EEA ^a	Slovenia	EU/EEA ^a
SSI surveillance period	2013	2013-2014	2013-2016	2013-2014	2013-2014	2013-2014	2013-2014	2013-2014	2013-2014	2013-2014
Number of hospitals	4	-	3	-	1	-	1	-	1	-
Number of operations	313	199 546	620	102 622	47	61 031	51	329 749	49	201 197
Median age (years)	31	31 ^d	55	56 ^d	75	69 ^d	71	72 ^d	72	70 ^d
ASA ^b ≥ 3 (%)	1.0	-	13.2	-	36.2	-	43.1	-	57.1	-
Urgent operations (%)	55.9	53.6 ^d	18.7	17.4 ^d	21.3	18.2 ^d	0	10.5 ^d	0	2.1 ^d
Contaminated or dirty wounds (%)	0	6.3 ^d	3.4	15.4 ^d	14.9	30.4 ^d	0	1.3 ^d	0	0.7 ^d
Antibiotic prophylaxis ^c (%)	91.4	84.6 ^d	27.3	48.3 ^d	97.9	90.2 ^d	94.1	97.2 ^d	89.8	98.2 ^d
Median duration of operation (minutes)	35	37 ^d	52	60 ^d	125	140 ^d	70	75 ^d	75	79 ^d
Total number of SSIs	14	4443	36	1855	13	5784	2	3553	0	1103
Median length of post-operative stay (days)	5	4 ^d	2	3 ^d	7	8 ^d	6	7 ^d	6	5 ^d
Number of post-operative patient-days	1 611	852 321	1 758	454 281	443	688 931	391	2 674 019	322	1 322 030
Total number of SSIs before discharge	6	594	12	684	11	3 902	1	1 231	0	256
SSIs cumulative incidence (%)	4.5	2.2	5.8	1.8	27.7	9.5	3.9	1.1	0	0.6
(95 % CI)	(2.5-7.4)	(2.2-2.3)	(4.1-7.9)	(1.7-1.9)	(15.6-42.6)	(9.2-9.7)	(0.5-13.5)	(1.0-1.1)	(0.0-7.3)	(0.5-0.6)
Individual Slovenian hospitals estimates	0 / 0 / 0,8 /13.8		3.3/4.0/ 22.1		NA		NA		NA	
Variation in European hospitals										
Mean	1.8		1.6		9.2		1.2		0.6	
Median	0.8		0.9		8.3		0.7		0.0	
(10th percentile - 90th percentile)	(0.0-4.7)		(0.0-4.3)		(1.4-18.1)		(0.0-3.1)		(0.0-1.8)	
In-hospital SSIs incidence density / 1000 post-operative patient-days	3.7	0.7	6.8	1.5	24.8	5.7	2.6	0.5	0	0.2
(95 % CI)	(1.4-8.1)	(0.6-0.8)	(3.5-11.9)	(1.4-1.6)	(12.5 - 44.0)	(5.5-5.8)	(0.1-14.2)	(0.4-0.5)	(0.0-11.4)	(0.2-0.2)
Individual Slovenian hospitals estimates	0 / 0 / 0 / 11.5		4.1 / 9.2 / 11.9		NA		NA		NA	
Variation in European hospitals										
Mean	0.7		1.4		5.6		0.5		0.2	
Median	0.0		0.0		4.8		0.0		0.0	
(10th percentile - 90th percentile)	(0.0-1.8)		(0.0-4.2)		(0.0-11.5)		(0.0-1.4)		(0.0-0.6)	

SSIs: surgical site infections; EU: European Union; EEA: European Economic Area; ASA: American Society for Anaesthesiology; CI: confidence interval; NA: not applicable (only one hospital); data was not available.

^a results of SSIs surveillance conducted in EU/EEA countries published by the European Centre for Disease Prevention and Control (see reference 7);

^b ASA score was ascertained according to the protocol for the surveillance of SSIs in Europe published by the European Centre for Disease Prevention and Control (see reference 9);

^c antibiotic prophylaxis within two hours before incision or during surgery for caesarean section;

^d results based only on patient-based data collected according to the protocol for the surveillance of in Europe published by the European Centre for Disease Prevention and Control (see reference 9).

A strikingly high in-hospital SSIs incidence density estimate was 11.5 in-hospital SSI (95% CI: 4.2-24.9) after caesarean section per 1000 post-operative patient-days in one hospital in comparison to the respective 90th percentile of 1.8 in-hospital SSIs per 1000 post-operative patient-days in EU/EEA hospitals (7). Another high estimate was 24.8 in-hospital SSIs (95% CI: 12.5-44.0) after colon surgery per 1000 post-operative patient-days in one hospital in comparison to the respective 90th percentile of 11.5 in-hospital SSIs per 1000 post-operative patient-days in EU/EEA hospitals (7). Also, the pooled estimate of 6.8 in-hospital SSIs (95% CI: 3.5-11.9) after cholecystectomy per 1000 post-operative patient-days for three Slovenian hospitals was rather high in comparison to the respective 90th percentile of 4.2 in-hospital SSIs per 1000 post-operative patient-days in EU/EEA hospitals (7).

In contrast, it was reassuring that the point estimates for in-hospital SSIs incidence density after cholecystectomy in one of the hospitals that conducted the SSIs surveillance continuously for three consecutive years, dropped from 9.8 in-hospital SSIs per 1000 post-operative patient-days in 2014 to 2.8 in-hospital SSIs per 1000 post-operative patient-days in 2016, although the differences were not statistically significant. The first point estimate was above and the later well below the 90th percentile of 4.2 in-hospital SSIs per 1000 post-operative patient-days in EU/EEA hospitals (7). It is well known that the surveillance of SSIs contributes to lowering their incidence (4, 5).

When interpreting our results, we should be cautious. The methods for the ascertainment of SSIs for surveillance purposes usually have lower than 100% sensitivity, which results in underestimations (13). In addition, the sensitivity and specificity of methods used for ascertaining SSIs may have varied between different hospitals and countries, which may have distorted comparisons. Regrettably, the numbers of patients enrolled in the Slovenian National SSIs surveillance system for the majority of different operation categories were rather low, which resulted in rather wide 95% CI for all estimations of SSIs incidence indicators making inferences about differences between Slovenian hospitals and comparisons to the reference data published for EU/EEA countries by ECDC difficult. Finally, as the number of hospitals participating, and the number of patients surveyed were rather low, this resulted in poor representativeness of the SSI surveillance data for Slovenia for the period 2013 to 2016.

5 CONCLUSIONS

These first results of the Slovenian National SSIs surveillance gave us some insight into the occurrence of SSIs in Slovenian acute care hospitals. The estimated

SSIs incidence rates varied between different surgical categories and different participating hospitals. There were rather high for some surgical procedures under surveillance in some participating hospitals in comparison to reference data for hospitals from EU/EEA countries published by ECDC. We can conclude that it is urgent to expand the standardised SSIs surveillance to all acute care hospitals with surgical wards in Slovenia to contribute to evidence-based SSIs prevention and control in Slovenian acute care hospitals. This could be supported by raising awareness of the importance of SSIs surveillance through regular annual meetings of the SSI-Sur network, the sub-network of HAI-Sur network, and regular annual feedback of the results to the participating hospitals.

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CONFLICTS OF INTEREST

No conflicts of interest exist.

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ETHICAL APPROVAL

The Medical Ethics Committee of the Republic Slovenia consented to the development and implementation of the National HAI surveillance, with one of its components, SSIs surveillance (consent number: 68/04/08).

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