Available online at www.sciencedirect.com

ScienceDirect

journal homepage: http://www.elsevier.com/locate/medici

Original Research Article

Healthcare-associated infections in Northern Russia: Results of ten point-prevalence surveys in 2006–2010

Ekaterina A. Krieger [a,b], *Andrej M. Grjibovski* [b,c,d,*], *Olga V. Samodova* [a], *Hanne M. Eriksen* [e]

[a] *Department of Infectious Diseases, Northern State Medical University, Arkhangelsk, Russia*
[b] *International School of Public Health, Northern State Medical University, Arkhangelsk, Russia*
[c] *International Kazakh-Turkish University, Turkestan, Kazakhstan*
[d] *Department of International Public Health, Norwegian Institute of Public Health, Oslo, Norway*
[e] *Department of Infectious Diseases Epidemiology, Norwegian Institute of Public Health, Oslo, Norway*

ARTICLE INFO

Article history:
Received 4 December 2014
Received in revised form
1 April 2015
Accepted 7 May 2015
Available online 16 June 2015

Keywords:
Healthcare-associated infections
Pediatric hospital
Russia

ABSTRACT

Background and objective: Statistics on healthcare-associated infections (HAIs) in Russia is scarce and has been considered to suffer from underreporting. We assessed the prevalence and changes in the prevalence of HAIs over 5 years and identified factors associated with acquiring HAIs in the pediatric hospital in Arkhangelsk, Northern Russia.
Materials and methods: Ten cross-sectional studies were conducted in the Arkhangelsk regional pediatric hospital biannually during 2006–2010. We used a standardized protocol, including the criteria of HAI proposed by the Centers for Disease Control and Prevention. Binary logistic regression was applied to study factors associated with HAI.
Results: Altogether, 3264 inpatients were enrolled in the study and 347 of them had HAI (11.2%). The prevalence of HAI per survey ranged from 7.1% (95% CI: 4.8%–10.4%) to 16.7% (95% CI: 13.1%–21.2%). The most prevalent HAIs were upper respiratory tract infections 5.1% (95% CI: 4.4%–5.9%), followed by urinary tract infections, 1.5% (95% CI: 1.2%–2.0%), and acute gastroenteritis, 1.4% (95% CI: 1.1%–1.9%). Compared to infants, children aged 5–9 years (OR = 0.7, 95% CI: 0.4–1.0), 10–14 years (OR = 0.4, 95% CI: 0.3–0.7), and ≥15 years (OR = 0.3, 95% CI: 0.2–0.5) were less likely to have HAI. Neutropenia (OR = 1.5, 95% CI: 1.0–2.3) and use of intravascular catheter(s) (OR = 1.8, 95% CI: 1.1–3.0) were positively associated with HAI.
Conclusions: The observed prevalence of HAIs is within the range reported in several other European countries. We do not recommend generalizing our findings to other Russian

* *Corresponding author at*: Department of International Public Health, Norwegian Institute of Public Health, Post Box 4404 Nydalen, 0403 Oslo, Norway. Tel.: +47 21078319.
E-mail address: andrej.grjibovski@gmail.com (A.M. Grjibovski).
Peer review under the responsibility of the Lithuanian University of Health Sciences.

Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.medici.2015.05.002

settings given considerable variations between regions in both socio-economic situation and conditions of medical facilities.

1. Introduction

Healthcare-associated infections (HAIs) represent a serious public health problem worldwide by increasing hospital mortality [1], duration of hospital stay [2] and cost of treatment [3]. Surveillance of HAI is regarded as an essential tool in infection control [4].

The overall prevalence of HAI ranges from 3.5% to 12.0% in high-income countries and from 5.7% to 19.1% in low- and middle-income countries [5]. In pediatric hospitals, the prevalence of HAIs has been reported to vary between 5.1% and 15.4% [6–10]. The highest prevalence of HAIs is often observed in intensive care units with pneumonia and sepsis being the most frequently reported sites of infection [11–13]. In general pediatric wards, the most prevalent HAI is viral gastroenteritis [10,14]. Age below 1 year, hospital stay for longer than 10 days, and use of urinary or intravascular catheters have been consistently shown to be associated with increased risk of HAI [2,9,14,15].

In Russia, notification of HAI became mandatory by law in 1990. Official documents defined HAI as infections originating in a patient in a hospital as well as occupational infections among hospital staff. The clear definition is not presenting a diagnostic time frame or specific criteria for different categories of HAIs. Each case of HAI has to be reported to the local Center of Federal service on customers' rights protection and human well-being surveillance (Rospotrebnadzor) within 12 h of detecting HAI. Rospotrebnazor is operating at local, regional and national level. Every month the local center reports data to the national Center of Rospotrebnadzor. Federal Statistics Service calculates and reports the incidence of HAIs. The following infections have to be reported: pyoseptical diseases of newborn and puerperant, surgical site infections, injection-acquired infections, urinary tract infections, pneumonia, acute gastrointestinal infections and viral hepatitis B and C [16].

According to Rospotrebnadzor, the incidence of HAIs decreased from 3.2 in 2005 to 0.8 per 1000 patients in 2010 [17,18]. However, according to another official source, the incidence of HAIs in Russia ranges between 1.4 in the Republic of Dagestan to 35.9 per 1000 patients in the Omsk region [19]. Scarce information and conflicting results on the incidence of HAI, in addition to several reports on lack of reliable statistics on HAIs in Russia, under-registration and the overall low quality of epidemiological surveillance [17,19–22], warrant alternative surveillance measures to provide a basis to enhance the practice of infection control in healthcare facilities.

Point-prevalence surveys are known as simple, cost-efficient, and time-saving surveillance options which are recommended by the European Council for HAI surveillance at regular intervals at the national or regional level [23]. The first point-prevalence survey of HAIs in Northern Russia was conducted in the Arkhangelsk regional pediatric hospital in February 2006 and revealed the prevalence of HAIs to be 17%, exceeding the prevalence in most European countries [24]. Since 2006, a surveillance of HAI was introduced in the hospital and 10 point-prevalence surveys have been performed between 2006 and 2010. This study aims to assess the prevalence and changes in the prevalence of HAIs over 5 years and to identify factors associated with acquiring HAIs in Arkhangelsk regional pediatric hospital.

2. Materials and methods

This paper summarizes results of ten point-prevalence surveys conducted in the Arkhangelsk regional pediatric hospital which is the largest pediatric hospital in the Arkhangelsk region. HAI was defined as a localized or systemic infection which was not present on admission or within the first 48 h of hospital stay as recommended by the Centers for Disease Control and Prevention [25]. The 48 h rule was not applied to surgical site infections so all surgical site infections occurring within 30 days after a surgery were included. The list of HAIs, which had to be registered, included all categories of HAIs according to the classification of the CDC [24]. If two HAIs were present in one patient, each infection was registered separately as described elsewhere [24].

We repeated one-day prevalence surveys covering all hospital wards between 2006 and 2010 twice yearly – one in December when respiratory tract infections and viral gastroenteritis are usual and one in April/May when bacterial intestinal infections are more common. All patients staying in the hospital for more than 48 h at 9 a.m. on the day of the survey were included. Demographic information and factors which have been shown in previous studies as significantly associated with HAI were studied [2,8,13,14]. These factors include patient's identification number, date of birth, gender, time of admission, surgery performed within 30 days prior to the day of the survey, neutropenia defined as absolute count of neutrophils <1500 per mm^3, the use of urinary or intravascular (central or peripheral) catheters and site of HAI, if present. Regularly trained infection control team led by a senior clinician collected the data using a standardized registration form. The team reviewed medical records and laboratory data as main sources of information. In disputable situations, attending physician and senior clinicians were consulted. More details about the data collection routines are presented elsewhere [24].

The prevalence of HAIs was calculated as number of infected patients divided by number of observed patients and was reported in percentage. We described the HAIs prevalence per survey, site of infections, hospital wards, age groups, length of hospital stay, presence or absence of neutropenia and urinary and intravascular catheters. Length of hospital stay was calculated as date of survey minus date of admission and was measured in days.

Continuous variables were skewed and therefore presented as medians with interquartile ranges (Q1; Q3). Nominal and categorical data are presented as absolute numbers and percentages. Confidence Intervals (CI) for proportions were calculated using Wilson's procedure [26]. Pearson's chi-squared tests were used to analyze categorical data. Associations between HAIs and potential risk factors were assessed using binary logistic regression. Neutropenia, the use of urinary, and intravascular catheters were entered as binary variables. The data on neutropenia were missing in 11 cases. In four cases, there were no data on use of urinary and intravascular catheters. Substitution of missing by "no" was decided a priori. The original missing values in the database were less than 1% and were recorded as "0". Children were classified into 5 age groups: <1, 1–4, 5–9, 10–14, and ≥15 years. The youngest age group was used as the reference group. Duration of hospital stay was divided into three categories: 3–7, 8–14, >14 days, with the shortest duration being the reference group. Patients of intensive care units were used as a reference group. Crude and adjusted odds ratios (OR) with 95% CI were calculated. Tests for linear trends were performed by introducing categories as continuous variables in the models. SPSS version 17.0 (SPSS Inc., Chicago, IL) was used for all analyses.

The study was approved by the ethical committee of the Northern State Medical University in Arkhangelsk.

3. Results

Altogether, 3264 inpatients (54% of males) comprised the sample. Most of the patients were from general pediatric wards (46.1%), followed by surgical wards (27.1%), infectious wards (20.3%), oncology and hematology wards (3.7%) and intensive care units (2.8%). One-fifth of the patients had surgery within 30 days prior to the survey day. The median age was 2 ($Q_1 = 1$; $Q_3 = 3$) years. The median duration of hospital stay for all patients was 12 ($Q_1 = 7$; $Q_3 = 20$) days. Basic characteristics of the sample are presented in Table 1.

Altogether 364 HAIs were registered among 347 patients. Eighteen patients (5%) had two infections at the same time. None of the patients had more than two infections.

During the study period, the overall HAI prevalence per survey varied between 7.1% and 16.7%. The HAIs prevalence over the 10 surveys is presented in Fig. 1. The prevalence of HAI tended to decrease (P for linear trend = 0.046) in crude analysis, but the trend did not reach the level of statistical significance after adjustment for other factors (Table 2).

The highest prevalence of HAIs was observed in the intensive care units and among patients with intravascular catheter and neutropenia (Table 2). In bivariate analysis, hospital ward, length of hospital stay, presence of neutropenia and intravascular catheter were significantly associated with HAI (Table 1).

The most prevalent HAIs were upper respiratory tract infections, 5.1% (95% CI: 4.4%–5.9%), followed by urinary tract infections, 1.5% (95% CI: 1.2%–2.0%), and acute gastroenteritis, 1.4% (95% CI: 1.1%–1.9%) both in April/May and December (Table 3). All seven cases of sepsis were among patients with intravascular catheters. Only 4 of the 50 urinary tract infections were among children with urinary catheters.

After adjustment, compared to children under the age of one year, children aged 5–9 years, 10–14 years, and ≥15 years were less likely to get HAI. Hospital stay for eight or more days was associated with HAI compared to the stay for less than seven days. The odds of having HAI increased with increased duration of stay in the hospital (P for linear trend <0.001). HAI was also associated with intravenous catheter use, but not with urinary catheter use. Patients hospitalized in December were less likely to get HAIs in comparison with those hospitalized in April/May. Patients from surgical wards had significantly lower odds for getting HAI compared to the patients from intensive care units (Table 2). We repeated the logistic regression analysis excluding individuals with missing data and the results remained unchanged.

4. Discussion

This paper presents the first experience of implementing institution-wide HAIs surveillance by regular point-prevalence surveys in Russia. Conducting point-prevalence surveys on a regular basis is in line with the practice recommended in Europe. The prevalence of HAIs observed in the study is within the range from 5.1% to 15.4% reported by other studies from pediatric hospitals [6–10], although direct comparisons should be avoided due to the differences in the methods used in different studies.

Consistent with earlier findings, infants had the highest odds of getting HAIs [8–10]. At the same time, this fact contradicted the Australian study where younger children were not at an increased risk of HAI [10]. The median duration of hospital stay observed in our study was twice as long as reported by Brazilian researchers [8]. Similar to findings from most other studies, duration of hospital stay for patients with HAIs was significantly higher than for non-infected patients [3,8]. Prolonged hospital stay is also an established risk factor for HAIs [9,10,24].

Hospitalization in intensive care unit was positively associated with HAI occurrence. This may be due to high exposure rates of patients in intensive care unit to invasive procedures as well as severe health conditions of patients that were not measured. In contrast to the other studies, we did not find associations between HAIs and the use of urinary catheters [9]. We suppose it could be due to sporadic usage of urinary catheter only for the purpose of diagnostics in our hospital. Persistent use of urinary catheter was only registered in a few cases.

We suppose the higher odds of HAIs among children hospitalized in December in comparison with those hospitalized in April/May may be partly explained by the higher incidence of upper respiratory tract infections that occurred during the spring over the last few years in Arkhangelsk. The distribution of HAIs according to the site of infection showed a relatively high prevalence of upper respiratory tract infections in contrasted to the predominance of sepsis, pneumonia and

Table 1 – Demographic and clinical characteristics of children with and without healthcare-associated infections in the Arkhangelsk regional pediatric hospital in 2006–2010.

Variables	Number of HAIs *N*	Infected children *N* (%)	Non-infected children *N* (%)	Total *N* (%)	*p**
	365	347 (11.2)	2917 (88.8)	3264 (100.0)	
Age, years					<0.001
<1	196	182 (15.0)	1034 (85.0)	1216 (100.0)	
1–4	101	100 (11.6)	764 (88.4)	864 (100.0)	
5–9	31	31 (6.3)	462 (93.7)	493 (100.0)	
10–14	22	22 (4.7)	447 (95.3)	469 (100.0)	
≥15	15	12 (5.4)	210 (94.6)	222 (100.0)	
Gender					0.537
Female	163	155 (10.3)	1354 (89.7)	1509 (100.0)	
Male	202	192 (10.9)	1563 (89.1)	1755 (100.0)	
Hospital wards					<0.001
Infectious wards	73	73 (11.0)	589 (89.0)	662 (100.0)	
General pediatric wards	191	175 (11.6)	1331 (88.4)	1506 (100.0)	
Surgical wards	57	55 (6.2)	828 (93.8)	883 (100.0)	
Oncology and hematology wards	21	21 (17.4)	100 (82.6)	121 (100.0)	
Intensive care units	23	23 (25.0)	69 (75.0)	92 (100.0)	
Hospital stay, days					<0.001
3–7	62	62 (6.2)	931 (93.8)	993 (100.0)	
8–14	109	104 (10.3)	906 (89.7)	1010 (100.0)	
>14	194	181 (14.4)	1080 (85.6)	1261 (100.0)	
Neutropenia					<0.001
Yes	43	39 (19.9)	157 (80.1)	196 (100.0)	
No	322	308 (10.0)	2760 (90.0)	3068 (100.0)	
Urinary catheters					0.107
Yes	8	8 (15.1)	45 (84.9)	53 (100.0)	
No	357	339 (10.6)	2872 (89.4)	3211 (100.0)	
Intravascular catheters					<0.001
Yes	44	44 (22.1)	155 (77.9)	199 (100.0)	
No	321	303 (9.9)	2762 (90.1)	3065 (100.0)	
Season					0.194
April/May	187	176 (11.4)	1372 (89.6)	1548 (100.0)	
December	178	171 (10.0)	1545 (90.0)	1716 (100.0)	
Year					0.010
2006	103	96 (13.4)	622 (86.6)	718 (100.0)	
2007	70	68 (10.4)	584 (89.6)	652 (100.0)	
2008	65	63 (8.3)	695 (91.7)	758 (100.0)	
2009	83	77 (12.0)	567 (88.0)	644 (100.0)	
2010	44	43 (8.7)	449 (91.3)	492 (100.0)	

* *p* values were calculated using the Pearson's chi-squared test.

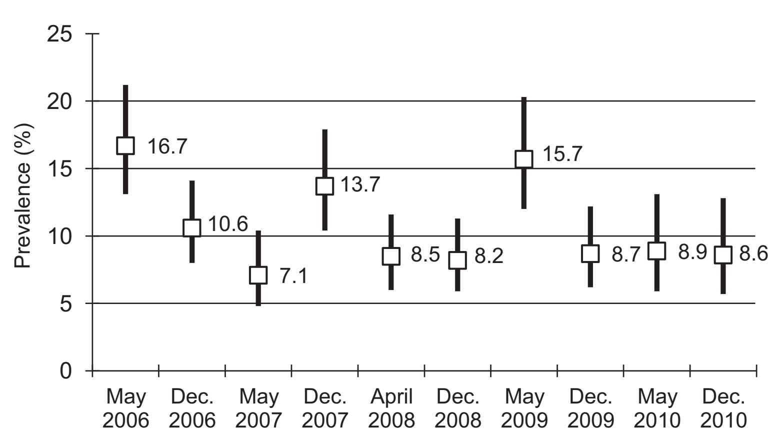

Fig. 1 – Prevalence of healthcare-associated infections in the Arkhangelsk regional pediatric hospital, 2006–2010.

Table 2 – Associations between healthcare-associated infections and studied factors in the Arkhangelsk regional pediatric hospital in 2006–2010.

Variables	Prevalence of HAIs % (95% CI)	Crude OR (95% CI)	p	Adjusted OR (95% CI)	p
Age, years					
<1	16.1 (14.2–18.3)	Reference	–	Reference	–
1–4	11.7 (9.7–14.0)	0.7 (0.6–1.0)	0.020	1.0 (0.7–1.4)	0.550
5–9	6.3 (4.5–8.8)	0.4 (0.3–0.6)	<0.001	0.7 (0.4–1.0)	0.001
10–14	4.7 (3.1–7.0)	0.3 (0.2–0.4)	<0.001	0.4 (0.3–0.7)	<0.001
≥15	6.7 (4.1–10.9)	0.3 (0.2–0.6)	<0.001	0.3 (0.2–0.5)	0.002
Test for trend		$p < 0.001$		$p < 0.001$	
Hospital wards					
Infectious wards	11.0 (8.9–13.6)	0.4 (0.2–0.6)	<0.001	0.6 (0.3–1.3)	0.260
General pediatric wards	11.6 (10.1–13.3)	0.4 (0.2–0.6)	<0.001	0.7 (0.3–1.4)	0.240
Surgical wards	6.2 (4.8–8.0)	0.2 (0.1–0.3)	<0.001	0.5 (0.2–1.0)	0.030
Oncology and hematology wards	17.4 (11.6–25.1)	0.6 (0.3–1.2)	0.170	0.8 (0.4–1.9)	0.570
Intensive care units	24.7 (17.1–34.4)	Reference	–	Reference	–
Hospital stay, days					
3–7	6.2 (4.9–7.9)	Reference		Reference	–
8–14	10.8 (9.0–12.9)	1.7 (1.2–2.4)	0.001	1.8 (1.3–2.5)	0.001
>14	15.3 (14.5–17.5)	2.5 (1.9–3.4)	<0.001	2.5 (1.8–3.5)	<0.001
Test for trend		$p < 0.001$		$p < 0.001$	
Neutropenia					
Yes	21.9 (16.7–28.2)	2.2 (1.5–3.2)	<0.001	1.5 (1.0–2.3)	0.41
No	10.5 (9.5–11.6)	Reference	–	Reference	–
Urinary catheter					
Yes	15.1 (7.9–27.1)	1.5 (0.7–3.2)	0.320	0.7 (0.3–1.7)	0.030
No	11.1 (10.1–12.3)	Reference	–	Reference	–
Intravascular catheter					
Yes	22.1 (16.9–28.4)	2.6 (1.8–3.6)	<0.001	1.8 (1.1–3.0)	0.030
No	10.5 (9.4–11.6)	Reference	–	Reference	–
Season					
April/May	12.1 (10.6–13.8)	Reference	–	Reference	–
December	10.4 (9.0–11.9)	0.9 (0.7–1.1)	0.200	0.8 (0.6–0.9)	0.020
Year					
2006	13.4 (11.1–16.1)	Reference	–	Reference	–
2007	10.4 (8.3–13.0)	0.8 (0.5; 1.0)	0.100	0.8 (0.6; 1.2)	0.250
2008	8.3 (6.6–10.5)	0.6 (0.4; 0.8)	0.002	0.6 (0.4; 0.8)	0.002
2009	12.0 (9.7–14.7)	0.9 (0.6; 1.2)	0.440	1.0 (0.7; 1.4)	0.960
2010	8.7 (6.6–11.6)	0.6 (0.4; 0.9)	0.010	0.7 (0.5; 1.0)	0.050
Test for trend		0.046		0.130	

surgical site infections observed in other studies [6,27–29]. Crowded wards with three to four children placed in one room with their mothers who take care for them, combined with inadequate ventilation, could be contributing factors to the high prevalence of upper respiratory tract infections in our hospital. After the exclusion of upper respiratory tract infections from the analysis, the overall prevalence of HAIs became 6% which is similar to the estimates in many European

Table 3 – Prevalence of different healthcare-associated infections across seasons in the Arkhangelsk regional pediatric hospital in 2006–2010.

Site of infection	April/May inpatients N = 1548		December inpatients N = 1716		Total inpatients N = 3264	
	No. of HAIs	Prevalence (%) 95% CI	No. of HAIs	Prevalence (%) 95% CI	No. of HAIs	Prevalence (%) 95% CI
Upper respiratory tract infections	100	6.5 (5.3–7.8)	67	3.9 (3.1–4.9)	167	5.1 (4.4–5.9)
Urinary tract infections	18	1.1 (0.7–1.8)	32	1.9 (1.3–2.6)	50	1.5 (1.2–2.0)
Acute gastroenteritis	19	1.2 (0.8–1.9)	27	1.6 (1.1–2.3)	46	1.4 (1.1–1.9)
Pneumonia	18	1.2 (0.7–1.8)	15	0.8 (0.5–1.4)	33	1.0 (0.7–1.4)
Surgical site infections	2	0.1 (0.0–0.4)	3	0.2 (0.0–0.5)	5	0.2 (0.1–0.4)
Sepsis	5	0.3 (0.1–0.7)	2	0.1 (0.0–0.4)	7	0.2 (0.1–0.4)
Asymptomatic bacteriuria	2	0.1 (0.0–0.4)	5	0.2 (0.1–0.7)	7	0.2 (0.1–0.4)
Others	23	1.5 (1.0–2.2)	27	1.6 (1.1–2.3)	50	1.5 (1.2–2.0)
Overall prevalence	187	12.1 (10.6–13.8)	178	10.4 (9.0–11.9)	365	11.2 (10.1–12.3)

settings [30]. The prevalence of urinary tract infections (1.3%) was as high as obtained in other European studies [28]. Acute gastroenteritis was common HAI in Arkhangelsk regional pediatric hospital. The results of a few published studies were similar and varied from 1.3% to 1.7% [6,8,31]. Other studies reported the prevalence of surgical site infections varying between 1.0% and 1.7% while in our study it was 0.1% [6,28,29,32]. Our findings can be, at least partially explained, by the use of antibiotics for surgical site infections prevention over several days after an emergency surgery. The prevalence of pneumonia and sepsis observed in the current study was low in comparison with other studies where the prevalence were 0.9% and 2.8%, respectively [6,27,29]. We did not find any data on asymptomatic bacteriuria in pediatric inpatients in other countries, but in our study it was reported relatively often.

The results should be interpreted taking into account potential limitations. The hospital does not have its own microbiological laboratory. Thus, some essential microbiological results were not available on the day of survey, which might have resulted in the underreporting of infections demanding microbiological confirmation. We want to emphasize, at this point, the high number of microbiology reports were available on patients with HAIs in the intensive care unit. We have identified some areas needing improvement. For example, there is a need for a ventilation system to prevent the spread of respiratory infections and the introduction of surgical antibiotic prophylactic regimes. The results of the study should be used to increase the awareness of infection control measures such as hand hygiene. We do not recommend generalizing our findings to other Russian settings given considerable variations between the regions in socio-economic situation and conditions of medical facilities in particular. However, the situation observed may reflect well current status with the HAIs in large regional level hospitals in North-Western part of Russia, which is relatively homogenous.

We have identified the areas requiring improvement in the hospital. In order to take the next step in improving of HAI surveillance, we recommend the use of repeated point-prevalence surveys as routine data collection in other hospitals in Russia, since prevalence surveys are a simple and cost-effective method with acceptable validity to monitor HAIs. Moreover, the use of the CDC definition for prevalence studies in Russia is recommended to ensure international comparability of the data. Better cooperation between hospitals and Rospotrebnadzor may improve transparency and comparability of HAI data in Russia with the international evidence.

5. Conclusions

The overall prevalence of HAIs in the study setting is similar to what was observed in several European settings. Moreover, the factors associated with HAI in our study are the same as in other countries. Although we did not observe a reduction in prevalence of HAI over time, international evidence suggests that surveillance routines may help to decrease HAI prevalence by increasing awareness among the medical staff and identifying need for the infection control measures.

Authors' contributions

E.A.K. participated in data-collection, performed the statistical analysis and interpretation of data, and drafted the manuscript. A.M.G. contributed to study design, data analysis, data interpretation and drafting the manuscript. O.V.S. participated in designing the study, data interpretation, conceived of the study and revised the manuscript. H.M.E. contributed to study design and interpretation the data. All authors have read and approved the final version of the manuscript.

Conflicts of interest

The authors declare no conflicts of interest. No additional funding to perform this study was received.

Acknowledgments

We thank Dr. Svetlana Nazarenko, who facilitated our work in the hospital. We thank the team of physicians and nurses who assisted in data collection.

REFERENCES

[1] Groeneveld AB. Risk factors for increased mortality from hospital-acquired versus community-acquired infections in febrile medical patients. Am J Infect Control 2009;37(1):35–42.
[2] Mahieu LM, Buitenweg N, Beutels P, De Dooy JJ. Additional hospital stay and charges due to hospital-acquired infections in a neonatal intensive care unit. J Hosp Infect 2001;47(3):223–9.
[3] Graves N, Weinhold D. Estimating the costs of hospital acquired infection. Clin Infect Dis 2010;50(7):1017–21.
[4] Haley RW, Culver DH, White JW, Morgan WM, Emori TG, Munn VP, et al. The efficacy of infection surveillance and control programs in preventing nosocomial infections in US hospitals. Am J Epidemiol 1985;121(2):182–205.
[5] World Health Organization. Report on the burden of endemic health care-associated infection worldwide; 2011. pp. 12–9.
[6] Rutledge-Taylor K, Matlow A, Gravel D, Embree J, Le Saux N, Johnston L. A point prevalence survey of health care-associated infections in Canadian pediatric inpatients. Am J Infect Control 2012;40(6):491–6.
[7] Avila-Figueroa C, Cashat-Cruz M, Aranda-Patrón E, Leon AR, Justiniani N, Perez-Ricardez L, et al. Prevalence of nosocomial infections in children: survey of 21 hospitals in Mexico. Salud Publica Mex 1999;41(1):18–25.
[8] Cavalcante SS, Mota E, Silva LR, Teixeira LF, Cavalcante LB. Risk factors for developing nosocomial infections among pediatric patients. Pediatr Infect Dis J 2006;25(5):438–45.
[9] Muhlemann K, Franzini C, Aebi C, Berger C, Nadal D, Stahelin S, et al. Prevalence of nosocomial infections in Swiss children's hospitals. Infect Control Hosp Epidemiol 2004;25(9):765–71.
[10] Burgner D, Dalton D, Hanlon M, Wong M, Kakakios A, Isaacs D. Repeated prevalence surveys of paediatric hospital-acquired infection. J Hosp Infect 1996;34(3):163–70.

[11] Annual epidemiological report on communicable diseases in Europe 2010. Stockholm: European Centre for Disease Prevention and Control; 2010. p. 1–185.
[12] Becerra MR, Tantalean JA, Suarez VJ, Alvarado MC, Candela JL, Urcia FC. Epidemiologic surveillance of nosocomial infections in a Pediatric Intensive Care Unit of a developing country. BMC Pediatrics 2010;10:66.
[13] Grohskopf LA, Sinkowitz-Cochran RL, Garrett DO, Sohn AH, Levine GL, Siegel JD. A national point-prevalence survey of paediatric intensive care unit-acquired infections in the United States. J Pediatr 2002;140(4):432–8.
[14] Mayon-White RT, Ducel G, Kereselidze T, Tikomirov E. An international survey of the prevalence of hospital-acquired infection. J Hosp Infect 1988;11(Suppl. A):43–8.
[15] Allegranzi B, Nejad SB, Combescure C, Graafmans W, Attar H, Donaldson L, et al. Burden of endemic health care-associated infection in developing countries: systematic review and meta-analysis. Lancet 2011;377(9761):228–41.
[16] Ministry of Health and social development of the Russian Federation. Normative document no 220 from September, 17th 1993. About measures of development and improvement of infectious service in the Russian Federation [Russian].
[17] Akopova NE, Maksakova EI. The sanitary-epidemiological conditions in the Russian Federation in 2004: State report. Moscow: Federal Center of Hygiene and Epidemiology of Rospotrebnadzor; 2005. p. 170–3 [Russian].
[18] Akopova NE, Petrov AE. The sanitary-epidemiological conditions in the Russian Federation in 2010. State report. Moskow: Federal Center of Hygiene and Epidemiology of Rospotrebnadzor; 2011. p. 314–5 [Russian].
[19] Rospotrebnadzor. The letter no 0100/10455-06-32 from September, 29th 2006. Incidence of Hospital-acquired infections in Russia in 2005. Improvement of epidemiological surveillance [Russian].
[20] Osipova VL. Hospital-acquired infections. Moscow: GEOTAR-Media; 2009. p. 8–11 [Russian].
[21] Akimkin VG. Classification of nosocomial infections and systematic approach to their prevention in a multi-profile hospital. Epidemiol Infect Dis 2003;8(5):15–9 [Russian].
[22] Onishchenko GG. Incidence of nosocomial infections in the Russian Federation. Gig Sanit 2008;74(3):4–6.
[23] Council Recommendation of 9 June 2009 on patient safety, including the prevention and control of healthcare-associated infections. Off J Eur Union 2009;1–6.
[24] Hajdu A, Samodova OV, Carlsson TR, Voinova LV, Nasarenko SJ, Tjurikov AV, et al. A point prevalence survey of hospital-acquired infections and antimicrobial use in a paediatric hospital in north-western Russia. J Hosp Infect 2007;66(4):378–84.
[25] Garner JS, Jarvis WR, Emori TG, Horan TC, Hughes JM. CDC definitions for nosocomial infections. Am J Infect Control 1988;16(3):128–40.
[26] Grjibovski AM. Confidence intervals for proportions. Hum Ecol 2008;14(5):57–60.
[27] Zarb P, Coignard B, Griskeviciene J, Muller A, Vankerckhoven V, Weist K, et al. The European Centre for Disease Prevention and Control (ECDC) pilot point prevalence survey of healthcare-associated infections and antimicrobial use. Eurosurveillance 2012;17(46): 4–19.
[28] Burns K, Foley M, Donlon S.Point prevalence survey of hospital-acquired infections & antimicrobial use in European Acute Care Hospitals: May 2012; 2012. p. 22.
[29] Reilly J, Stewart S, Allardice G, Noone A, Robertson C, Walker A, et al. NHS Scotland national HAI prevalence survey. Final Report 2007. Glasgow, Scotland: Health Protection Scotland; 2007. p. 189.
[30] Signorelli C, D'Alessandro D, Collina D, Fara GM. Prevalence survey of nosocomial infections in a paediatric hospital. J Hosp Infect 1991;18(2):139–43.
[31] Ford-Jones EL, Mindorff CM, Langley JM, Allen U, Navas L, Patrick ML, et al. Epidemiologic study of 4684 hospital-acquired infections in pediatric patients. Pediatr Infect Dis J 1989;8(10):668–75.
[32] Porras-Hernadez JD. A prospective study of surgical site infections in a pediatric hospital in Mexico City. Am J Infect Control 2003;31(5):302–8.