Prescription of antibiotics in Riga and Vilnius tertiary children's hospitals

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ABSTRACT

Objectives The aim of this study was to compare the use of antibiotics among hospitalised children in Riga (Latvia) and in Vilnius (Lithuania) at two tertiary paediatric centres.

Methods A point prevalence survey (PPS) was conducted using validated and standardised Antibiotic Resistance and Prescribing in European Children (ARPEC) project methodology during November 2012. All inpatients less than 18 years old were included in the study. All data were recorded for patients with active antimicrobial prescriptions at 8 am on the day of the survey. Data were entered into the ARPEC-webPPS programme and were validated online for accuracy.

Results The proportion of patients receiving antimicrobial therapy was statistically different: 128 (37.0%) patients in Riga and 83 (26.3%) in Vilnius. The most common age group in Riga and Vilnius was 1–5 years. The most commonly used antibiotic classes for the treatment and prophylaxis of infection were third-generation cephalosporins (38; 25.5% prescriptions) in Riga and second-generation cephalosporins (16; 19.8%) in Vilnius. Parenteral use of antimicrobials was higher in Riga than in Vilnius: 111 (74.5%) prescriptions to paediatric patients in Riga and 45 (55.6%) prescriptions in Vilnius.

Conclusions The PPS identified differences in antibiotic use in both hospitals and problem areas for improvement: high use of third-generation cephalosporins for paediatric patients (in Riga) and predominant use of parenteral antibiotics. Further collaboration between both centres is needed because sharing audit data and antimicrobial stewardship initiatives may encourage further changes in practice at both institutions.

INTRODUCTION

Inappropriate antibiotic use increases both microbial resistance and hospital costs. According to the European Centre for Disease Prevention and Control (ECDC) there is high resistance to antibiotics among Gram-positive and Gram-negative bacteria and it is estimated that there are about 25 000 patient deaths every year due to multi-drug-resistant bacteria in the European Union.¹ Although in European countries antibiotics are used mainly in primary care centres, hospitals are considered to be the centre of antimicrobial resistance due to high prescription rates of broad spectrum agents in both adults and children.² According to some reports, up to 50% of antibiotic prescribing in hospitals is inappropriate.³ Antibiotics are among the most common medicines given to children^{4,5}

Key messages

What is already known on this subject

- ▶ Inappropriate antibiotic use may increase both microbial resistance and hospital costs.
- ▶ Antibiotics are among the most common medicines given to children.

What this study adds

- ▶ This study identified differences in antibiotic use in both hospitals and problem areas for improvement, for example, predominant use of parenteral antibiotics.
- ▶ The study shows a convenient and efficient way to analyse antibiotic usage tendencies in hospitalised children.
- ▶ Hospital pharmacists could play an important role in multidisciplinary teams responsible for antibiotic stewardship programmes.

and up to 60% of children receive at least one antibiotic during their hospital stay.⁶ There is an urgent need to change prescribing practice for children through improved antimicrobial stewardship and identification of the factors which have the greatest influence on antimicrobial prescribing.⁷ One of the recommendations of the Council of the European Union to decrease misuse of antibiotics and control healthcare-associated infections is to organise point prevalence surveys (PPS) on a regular basis.⁸ PPS can be an alternative method to electronic prescribing for identifying antibiotic usage trends.⁹ It is very important to analyse antibiotic prescription trends in neighbouring countries because there could be similar resistance tendencies. The aim of this study was to compare the use of antibiotics among hospitalised children in Lithuania and Latvia at two tertiary paediatric centres because sharing audit data and antimicrobial stewardship initiatives may encourage further changes in practice at both institutions. This study is important because there is still a lack of comparison studies of antimicrobial consumption in hospitalised children in the same regions.

METHODS

This study was a part of the Antibiotic Resistance and Prescribing in European Children (ARPEC) project co-funded by the European Commission Directorate General for Health and Consumers (DG SANCO) through the Executive Agency for Health and Consumers. A PPS was conducted at two tertiary-care children's hospitals: University Children's Hospital in Riga (Latvia) and Vilnius University

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Table 1 Patients' characteristics

Characteristics	Riga N (%) (95% CI)	Vilnius N (%) (95% CI)
No. of beds	476	415
Bed occupancy	(72.7) (60.0 to 77.0)	(75.9) (71.8 to 80.1)
Total No. of patients	346	315
Treated patients all antimicrobials	128 (37.0) (32.1 to 42.2)	83 (26.3) (21.8 to 31.4)
Gender (on antibiotics)		
Male	73 (57.0) (48.4 to 65.6)	39 (47.0) (36.3 to 57.7)
Female	55 (43.0) (46.4 to 63.6)	44 (53.0) (42.3 to 63.7)
Age range		
0<29 days	12/128 (9.4) (4.0 to 14.0)	12/83 (14.5) (6.5 to 21.5)
≥29 days≤1 year	21 (16.4) (9.7 to 22.3)	14 (16.9) (8.9 to 25.1)
>1 year≤5 years	36 (28.1) (20.2 to 35.8)	26 (31.3) (21.1 to 41.0)
>5 years≤12 years	34 (26.6) (19.3 to 34.7)	13 (15.6) (8.1 to 23.9)
>12 years	25 (19.5) (13.1 to 26.9)	18 (21.7) (13.1 to 30.9)

Children's Hospital, Affiliate of Vilnius University Hospital Santariskiu Klinikos (Lithuania) using validated and standardised ARPEC methodology.^{7–10} Each hospital was registered on the ARPEC database which provided the name, the geographical location and the type of hospital (primary, secondary or tertiary level and specialised teaching hospital vs non-teaching hospital). Seven major paediatric ward types (general paediatric medicine, four types of specialised paediatric medicine wards, paediatric surgery, paediatric intensive care unit (PICU) and four major neonatal wards were defined (three levels of neonatal intensive care units (NICUs) and a general neonatal medical ward). All data were collected by the ARPEC study personnel in each clinic: doctors (in Vilnius) and a clinical pharmacist (in Riga). All data collected were completely anonymous. All inpatients less than 18 years old at 8 am on the day of the survey (and present at least since midnight) were included in the study. Day-case patients, outpatients, emergency admissions and patients in psychiatry clinics were excluded. Detailed data were recorded only for patients with active antimicrobial prescriptions at 8 am on the day of the survey. Paediatric surgical wards were not audited on a Monday in order to capture information about prophylaxis in the previous 24 hours (duration of prophylaxis was either one dose, 1 day or >1 day). Wards were not audited on holidays and weekend days. Two different data collection forms for paediatric and neonatal patients were used. The following data were collected: patient demographic details, for example, gender, age, weight (birth weight and gestational ages for neonates), ventilation status, underlying diagnosis, prescribed antimicrobials (ATC classes J01, J02, J05, J04A, A07AA, D01BA, P01AB), indication, single dose and number of doses per day, frequency, route of administration, reason for treatment, prophylaxis (medical or

surgical). The total number of patients and beds available on the day of the PPS were recorded. The reason for the treatment for paediatric patients was divided into 21 categories. The reason for the treatment for neonatal patients was divided into 18 categories. Each antimicrobial was allocated to a single treatment category. The underlying diagnosis had to be completed in the case of a chronic pre-existing disease. All data were collected from the inpatient medication charts and the patients' medical notes. Data were entered into the web-based application ARPEC-webPPS which was designed for this project and which was used for data entry, online validation for accuracy and reporting. The use of this platform allowed data collection in the standardised way and comparison of results from different clinics. Hospitals then extracted their data for analysis in Microsoft Excel.⁷ Data were analysed using the SPSS 20.0 software package. Descriptive statistics was used for prescription data and demographics. 95% CIs for percentages were calculated. The χ^2 test was used to compare categorical values. A p-value less than 0.05 was accepted as statistically significant. This study was a 1-day PPS with no interference of the standard treatment. It included all hospitalised neonatal and paediatric patients. Therefore, both in Riga and Vilnius this study was considered a part of other studies performed and no additional ethics committee approval was requested for this particular analysis. Patients included in this study were not given any study-related medicines and no study-related samplings or procedures were performed. All study subjects received medications according to the standard guidelines and practices of the hospital. The objective of this study was to evaluate practices relating to the use of antibiotics in the clinics but not to collect individual data. Therefore after consultations with the ethics committee it was decided not to ask the parents for informed consent.

RESULTS

Tables 1 and 2 show the demographic data from both hospitals.

There was not a statistically significant difference between bed occupancy in Riga and Vilnius (χ^2 test, $p=0.306$). The proportion of patients receiving antimicrobial therapy was different in the two study centres: 128 (37.0%) in Riga and 83 (26.3%) in Vilnius and the difference was statistically significant (χ^2 test, $p=0.003$). The most common age group in Riga and Vilnius was 1–5 years, with male patients making up a greater proportion of inpatients in Riga and female patients in Vilnius. There was not a statistically significant difference between the number of patients receiving antibiotics in paediatric surgery in Riga and Vilnius (χ^2 test, $p=0.165$) but it was statistically different for patients in medical specialties (χ^2 test, $p=0.04$) (table 2). In Vilnius only antibiotics belonging to the ATC J01 class were used during the study period but in Riga there were seven prescriptions of antimicrobials belonging to the J02AC class and one prescription for a J05AF class antimicrobial. In Riga, 20 different antibiotics

Table 2 Patients' characteristics by specialties

Specialty	Riga			Vilnius		
	Total No. of patients	Patients on antibiotics, N (%)	Percentage of total on antibiotics, N (%)	Total No. of patients	Patients on antibiotics, N (%)	Percentage of total on antibiotics, N (%)
Paediatric intensive care	7	7 (100)	7/128 (5.5)	2	1 (50.0)	1/83 (1.2)
Paediatric surgery	69	18 (26.1)	18/128 (14.1)	62*	10 (16.1)	10/83 (12.0)
Medical	232	89 (38.4)	89/128 (69.5)	199	58 (29.1)	58/83 (69.9)
Neonatal	27	13 (48.1)	13/128 (10.2)	45	9 (20.0)	9/83 (10.8)
NICU	11	1 (9.1)	1/128 (0.8)	7	5 (71.4)	5/83 (6.0)

*Traumatology+surgery+orthopaedics.

Table 3 Antibiotic classes used for the treatment and prophylaxis of paediatric patients

WHO ATC	Prescriptions (total N: treatment & prophylaxis)	
	Riga	Vilnius
	n=149 (%)	n=81 (%)
Penicillins with extended spectrum (J01CA)	20 (13.4)	13 (16.0)
β-lactamase sensitive penicillins (J01CE)	11 (7.4)	5 (6.2)
β-lactamase resistant penicillins (J01CF)	5 (3.4)	2 (2.5)
Combinations of penicillins, including β-lactamase inhibitors (J01CR)	1 (0.7)	0
First-generation cephalosporins (J01DB)	8 (5.4)	5 (6.2)
Second-generation cephalosporins (J01DC)	18 (12.1)	16 (19.8)
Third-generation cephalosporins (J01DD)	38 (25.5)	6 (7.4)
Carbapenems (J01DH)	1 (0.7)	1 (1.2)
Combinations of sulfonamides and trimethoprim, including derivatives (J01EE)	12 (8.1)	8 (9.9)
Macrolides (J01FA)	8 (5.4)	9 (11.1%)
Lincosamides (J01FF)	4 (2.7)	3 (3.7)
Other aminoglycosides (J01GB)	7 (4.7)	8 (9.9)
Glycopeptide antibacterials (J01XA)	2 (1.3)	1 (1.2)
Imidazole derivatives (J01XD)	6 (4.0)	1 (1.2)
Nitrofurane derivatives (J01XE)	0	3 (3.7)
Triazole derivatives (J02AC)	7 (4.7)	0
Nucleoside and nucleotide reverse transcriptase inhibitors (J05AF)	1 (0.7)	0

and in Vilnius 18 different antibiotics were used for the prophylaxis and treatment of paediatric patients. The frequency of prescribed antibiotic classes is listed in [table 3](#).

The most commonly used antibiotic classes for the treatment and prophylaxis of infection were the third-generation cephalosporins in Riga, 38 (25.5%), and the second-generation cephalosporins in Vilnius, 16 (19.8%). In Riga, 25/116 (21.6%; 95% CI 14.5 to 29.5) paediatric patients and 7/12 (58.3%; 95% CI 30.1 to 85.9) neonates and in Vilnius 9/71 (12%; 95% CI 5.2 to 20.8) paediatric patients and 9/12 (75.0%; 95% CI 50.5 to 99.5) neonates received more than one antibiotic. In Riga, the top three antibiotics used in paediatric patients for treatment and prophylaxis were ceftriaxone 24 (16.1%), cefuroxime and amoxicillin each 18 (12.1%); in Vilnius, they were cefuroxime 16 (19.8%), amoxicillin 13 (16.0%) and clarithromycin 9 (11.1%) prescriptions. [table 4](#) shows the therapeutic indications of paediatric patients.

Paediatric lower respiratory tract infections (pneumonia and other) (LRTIs) were the most common indications for antibiotic use in both hospitals: in Riga 39 (26.2%) prescriptions and in Vilnius 17 (21.0%) prescriptions. For neonates the most common reason for treatment was prophylaxis for newborn risk factors and sepsis: each 5/19 (26.3%) in Riga and other/unknown reason 12/24 (50.0%) prescriptions in Vilnius. Other reasons for neonates' treatment in Riga were as follows: LRTI 4/19 (21.1%), prophylaxis for maternal risk factors 3/19 (15.8%) and prophylaxis for surgical disease 2/19 (10.5%) prescriptions. In Vilnius other reasons were as follows: sepsis 5/24 (20.3), treatment for surgical disease 4/24 (16.7%), prophylaxis for newborn risk factors 2/24 (8.3%) and LRTI 1/24 (4.2%) prescriptions. Antibiotics used for the treatment of LRTIs in paediatric patients are shown in the [table 5](#).

Table 4 Therapeutic indications of paediatric patients

Reason for treatment / No. of prescriptions	Riga	Vilnius
	n=149 (%)	n=81 (%)
Prophylaxis for surgical disease	13 (8.7)	9 (11.1)
Treatment for surgical disease	12 (8.1)	8 (9.9)
Prophylaxis for medical problems	23 (15.4)	4 (4.9)
Bacterial LRTI	30 (20.1)	15 (18.5)
Viral LRTI	9 (6.0)	2 (2.5)
Upper respiratory tract infections	14 (9.4)	7 (8.6)
Urinary tract infections	7 (4.7)	8 (9.9)
Sepsis	5 (3.4)	5 (6.2)
Acute otitis media	9 (6.0)	3 (3.7)
Lymphadenitis	4 (2.7)	0
Joint/bone infections	6 (4.0)	1 (1.2)
CNS infections	2 (1.3)	0
Fever of unknown origin	2 (1.3)	8 (9.9)
Febrile neutropenia / fever in patients with oncological conditions	7 (4.7)	0
Skin/soft tissue infections	2 (1.3)	2 (2.5)
Other/unknown	3 (2.0)	3 (3.7)
GI tract infections	1 (0.7)	6 (7.4)

CNS, central nervous system; GI, gastrointestinal; LRTI, lower respiratory tract infection.

In Vilnius all (17) paediatric LRTIs (bacterial and viral) were community-acquired infections; in Riga 37 prescriptions were for community-acquired infections and 1 prescription (clindamycin) was for aspiration pneumonia. The reason for 12/38 (31.6%) of all prescriptions of third-generation cephalosporins in Riga was LRTI (bacterial and viral), but there were none in Vilnius. The most common age group of patients with LRTI in both hospitals was under 5 years of age: 22/39 (56.4%) in Riga and 8/15 (53.3%) in Vilnius. In Riga the parenteral route was used in 31/38 (81.6%) paediatric patients; in Vilnius, only 5/17 (29.4%) cases of LRTI were treated in this way. Antibiotics given for surgical prophylaxis in both hospitals in most cases was for longer than 1 day: in Riga all 13 prescriptions and in Vilnius 8/9 (88.9%) prescriptions. In Riga the antibiotics used were ceftriaxone and cefazolin each 4/13 (30.8%) prescriptions, cefuroxime 2 (15.4%) prescriptions, and oxacillin, amoxicillin and metronidazole each 1 (7.7%) prescription. One patient

Table 5 Antibiotics used for the treatment of LRTIs in paediatric patients

Antibiotics	Riga	Vilnius
	n=30 (%)	n=15 (%)
Bacterial LRTI / No. of prescriptions		
Amoxicillin	9 (30.0)	6 (40.0)
Clarithromycin	7 (23.3)	8 (53.3)
Cefuroxime	3 (10.0)	1 (6.7)
Ceftriaxone	7 (23.3)	0
Cefotaxime	3 (10.0)	0
Clindamycin	1 (3.4)	0
Viral LRTI / No. of prescriptions	n=8 (%)	n=2 (%)
Amoxicillin	3 (37.5)	0
Ceftriaxone	2 (25.0)	0
Cefuroxime	2 (25.0)	0
Cefotaxime	1 (12.5)	0
Benzylpenicillin	0	1 (50.0)
Clindamycin	0	1 (50.0)

Table 6 Antibiotics used for the treatment and prophylaxis of neonates

Antibiotics	Riga	Vilnius
No. of prescriptions	n=19 (%)	n=25 (%)
Benzylpenicillin	6 (31.5)	8 (32.0)
Gentamicin	5 (26.3)	8 (32.0)
Cefotaxime	0	3 (12.0)
Meropenem	0	3 (12.0)
Ceftazidime	0	3 (12.0)
Ampicillin	2 (10.5)	0
Amoxicillin	2 (10.5)	0
Imipenem	1 (5.3)	0
Amikacin	1 (5.3)	0
Metronidazole	1 (5.3)	0
Ceftriaxone	1 (5.3)	0

received a combination of ceftriaxone and oxacillin. The antibiotics used for surgical prophylaxis in Vilnius were co-trimoxazole and benzylpenicillin each 2/9 (22.2%) prescriptions, cefotaxime, vancomycin, oxacillin, cefazolin and nitrofurantoin each 1 (11.1%). One patient received a combination of cefotaxime and vancomycin. In Vilnius the second-generation cephalosporins (cefuroxime) were used mainly for the treatment of surgical diseases: 5/8 (62.5%) prescriptions, 2 prescriptions in the urology department and 3 in the ear, nose and throat department. In Riga, cefuroxime made up only 2/12 (16.7%) prescriptions for surgical diseases: in cardiac surgery and abdominal surgery. Neonatal patients received 8 different antibiotics in Riga and 5 different antibiotics in Vilnius. Antibiotics used for the treatment and prophylaxis of neonates are listed in [table 6](#).

Parenteral use of antimicrobials in paediatric patients was higher in Riga than in Vilnius: 111/149 (74.5%; 95% CI 68.1 to 82.0) prescriptions in Riga and 45/81 (55.6%; 95% CI 45.2 to 66.8) prescriptions in Vilnius. This difference was statistically significant (χ^2 test, $p=0.003$). All neonates in Riga and Vilnius received only parenteral antibiotics: 19 prescriptions in Riga and 24 in Vilnius. The indication for a given therapy was not provided in 1/149 (0.7%) medical records for paediatric patients in Riga and in 2/81 (2.5%) in Vilnius. It was given in all 19 medical records for neonatal patients in Riga and in all 24 medical records for neonatal patients in Vilnius.

Antibiotics were prescribed empirically (ie, the antibiotic is being used as per a local guideline, as a best guess treatment by means which experience has proved to be beneficial) to paediatric patients in 124/149 (83.2%; 95% CI 77.0 to 89.0) cases in Riga and 75/83 (90.4%; 95% CI 87.5 to 98.5) cases in Vilnius. This difference was not statistically significant (χ^2 test, $p=0.136$). Antibiotics were prescribed empirically to neonates in 3/19 (15.8%) cases in Riga and 22/24 (91.7%) cases in Vilnius. In 42/116 (36.2%; 95% CI 27.3 to 44.7) children in Riga and 39/71 (54.9%; 95% CI 42.4 to 65.6) children in Vilnius there were underlying diseases. This difference was statistically significant (χ^2 test, $p=0.012$). Pre-existing comorbidities were present in 7/12 (58.3%) neonates in Riga and all 12 (100%) neonates in Vilnius.

DISCUSSION

This study provides a comparison of antibiotic use in two tertiary paediatric hospitals in two neighbouring European countries, thus enabling a comparison of practice. It might be assumed that population, spectrum of pathology and patterns of antimicrobial

resistance are comparable in the two hospitals. However, we have identified a number of variations in antibiotic prescribing in our study. In Riga the parenteral use of antimicrobials in paediatric patients was higher than in Vilnius: 111 (74.5%) versus 45 (55.6%) prescriptions. This might be due to severity of patients' conditions or social acceptance that intravenous antibiotics are 'stronger' compared with oral antibiotics in the treatment of infection in hospitalised patients. While some infections require parenteral use (eg, infections of the central nervous system), the disproportionately high use of intravenous antibiotics should be reduced in Riga. Such a route of administration is associated with higher costs, extra work for nurses and vascular line complications.¹¹ The third-generation cephalosporins (ceftriaxone and cefotaxime) in Riga were mostly used for LRTI treatment (as well as amoxicillin), while in Vilnius clarithromycin and amoxicillin were used for this treatment. According to local guidelines used in the university children's hospital in Riga, the antibiotic of choice for patients with pneumonia is amoxicillin; macrolides could be used in the case of penicillin allergy for patients aged 3 months to 5 years. For patients with severe pneumonia who are over 1 year of age, the antibiotic of choice is cefuroxime, ceftriaxone or cefotaxime. But for critically ill patients over 1 year of age, the antibiotic treatment of choice is cefotaxime and oxacillin, or alternatively, cefuroxime or ceftriaxone and erythromycin. For patients 5–18 years old macrolides are the antibiotics of choice; patients with severe pneumonia and critically ill patients in this age group have to be treated with cefuroxime or ceftriaxone and erythromycin or azithromycin. According to French guidelines and the British Thoracic Society's guidelines, amoxicillin should be used as a first choice for oral antibiotic therapy in all children.¹² Similar recommendations are proposed by the experts of the European Society for Paediatric Infectious diseases (ESPID).¹³

Use of macrolides was low in both hospitals. One of the explanations for this could be that the biggest patient group with LRTI was those under 5 years old in whom macrolides are not the antibiotic of choice. Macrolides use should be carefully considered in patients, especially those who do not respond appropriately to these antibiotics. A recent Italian study reports the high prevalence of macrolide-resistant genotypes in children.¹⁴ Antibiotic prescribing patterns might be influenced by local resistance patterns. PPS methodology does not allow evaluation of the appropriateness of the antibiotic choice. Another analysis would be necessary to explain, for instance, the high use of third-generation cephalosporins in Riga. The third-generation cephalosporins were the most often used antibiotic group in Riga ([table 3](#)). Results from other point-prevalence studies and defined daily dose (DDD) studies (taking into account all limitations that DDD studies have in the paediatric population) performed in the hospital show that there is an increasing tendency for third-generation cephalosporin usage.^{15 16} One of explanations could be that ceftriaxone may be administered once or twice per day compared with penicillins (three or four times per day). There is also a need for qualitative studies of physicians' behaviour; that is, why do they choose ceftriaxone for the treatment of, for example, severe pneumonia and not other antibiotics that are mentioned in the local guidelines? Some of the local guidelines in Riga (eg, pneumonia and surgical prophylaxis) are partly based on American guidelines where cephalosporins are quite popular (although they also suggest amoxicillin as one of the first-choice antibiotics for pneumonia treatment) compared with Scandinavian (Nordic) recommendations where penicillins are antibiotics of choice in many cases. But some local hospital opinion leaders in Riga do not consider

that these Scandinavian recommendations have the same level of evidence as, for example, American or British guidelines, therefore they prefer to follow the latter guidelines.

Perioperative antibiotic use was not focused on in this study. However, further analysis would be beneficial in the choice of agents, appropriateness of prophylaxis, and especially duration of treatment as our results in both hospitals show that in most cases prophylaxis was longer than one day, which is not usually required. These results are similar to other studies in which the inappropriate length of antibiotic use for surgical prophylaxis has been reported.^{17–19} We cannot compare the use of second-generation cephalosporins, which was the most often used antibiotic group in Vilnius and mainly used in the treatment of surgical disease, as they were used in different departments; for example, there were no patients in the urology department in Riga during the study period who received antibiotics. It would be necessary to decrease cephalosporin use, especially third-generation cephalosporins. Third-generation cephalosporins should be used with caution, taking into account growing resistance problems.^{20–21} At the same time, this needs to be analysed carefully as for example a recent Swedish study showed that the consumption of cephalosporins has decreased in Swedish hospitals but they were replaced by carbapenems, penicillinase-sensitive penicillins or some other antibiotics.²² The high use of cephalosporins in Riga and Vilnius is similar to findings in other studies in which cephalosporins in general and ceftriaxone in particular were among the most frequently used antibiotics.^{11–17–23–25} Non-restricted use of third-generation cephalosporins could lead to an increase of resistant *Escherichia coli* and *Klebsiella pneumoniae*. Our results differ from other studies in which macrolides were among the most frequently used antibiotics.²⁶ In Riga, there are currently no restrictions on antibiotic choice. There are hospital recommendations for community-acquired pneumonia treatment. Recommendations for surgical prophylaxis were approved after this study (in September 2013) as a result of a collaboration of different specialists, including a clinical pharmacist who initiated the development of these recommendations. The antimicrobial stewardship team was established in Riga in order to improve antibiotic usage in the hospital. A clinical pharmacist became the chair of this committee. Although there are some data showing that restrictive methods (formulary restrictions, regular reviews by pharmacists in wards etc) are more effective than educational interventions (mostly in the short term)³ there is a need for both: local guidelines with restriction measures (in Riga) as well as educational programmes in both hospitals.^{27–29} A third-day antibiotic prescription evaluation might be one possible intervention used to improve antibiotic prescribing patterns, at least in Riga.³⁰ Currently an electronic prescription programme of medicines is being implemented in Riga that will help clinical pharmacists to evaluate antibiotic prescriptions (duration, dosages etc), compared with medical records in paper forms.

The strength of this study is the validated and standardised methodology that allows comparison of antibiotic use. Differences in the used methodologies, numerators and denominators make it difficult to compare this study with others.^{6–11–25} Some studies analyse antibiotic use in a particular hospital or even hospital wards.^{23–24–31} A multidisciplinary approach (different specialists including a clinical pharmacist who did the analysis) should also be considered a strength of this study. There are some limitations of this study. First, the PPS methodology does not allow a large number of patients to be included and we have to be careful with generalisation of the study results.

It is not possible to analyse whether the treatment was correct for a particular infection. We were also not able to analyse the duration of antibiotic use.

CONCLUSIONS

The PPS identified differences in antibiotic use in both hospitals and problem areas for improvement: high use of third-generation cephalosporins for paediatric patients (in Riga) and predominant use of parenteral antibiotics. Although the PPS has limitations, for example no data on local resistance patterns informing antibiotic choice or how long antibiotics were used, it is a useful method to identify areas of improvement.

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Contributors IS conceived, initiated and designed the study, prepared all the study documents, was the leading investigator in Latvia and drafted the manuscript. VU conceived, initiated and designed the study, prepared all the study documents, and was the leading investigator in Lithuania. DM contributed to the preparing of the manuscript and Latvian data analysis. VG, II and SB coordinated the study, enrolled the patients in Vilnius University Children's Hospital, were responsible for data management, and performed the statistical analysis. All authors read and approved the final manuscript.

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