CURRENT OPINION

Drugs 2011; 71 (6): 745-755
0012-6667/11/0006-0745/$55.55/0

European Surveillance of Antimicrobial Consumption (ESAC)

Value of a Point-Prevalence Survey of Antimicrobial Use Across Europe

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Abstract

All 27 EU member states and another seven countries participate in the European Surveillance of Antimicrobial Consumption (ESAC) project. ESAC carried out three hospital point-prevalence surveys on antimicrobial use. Point-prevalence surveys linked antimicrobial use to indication and also assessed dosing using a standardized methodology for data collection and online data submission with feedback capability using a dedicated web-based tool. The objectives of the ESAC hospital point-prevalence surveys were to first determine the feasibility of a pan-European survey and identify targets for quality improvement.

Hospitals were voluntarily selected by the lead national or hospital representatives for each country. The WHO Anatomical Therapeutic Chemical Classification of drugs was used for classification of antimicrobials. The three surveys were carried out during a maximum of 2 weeks in the second quarter of 2006, 2008 and 2009. Each department had to be surveyed in 1 day. All systemic antibacterials (J01), rifampicin (J04AB), oral vancomycin (A07AA) and oral/rectal metronidazole (P01AB) were the antimicrobials surveyed, including the prescribed regimen.

The number of participating hospitals increased from 20 to 172 from 2006 to 2009. The patient demographics and indications for treatment were similar throughout the three point-prevalence surveys. 'Reason in notes' and 'surgical prophylaxis >24 hours' were also similar. Guideline compliance (51%) was only introduced in the 2009 point-prevalence survey, replacing 'sample for culture and sensitivity' (<50% in 2006 and 2008) since samples were either not taken or no information was available for the majority (>50%) of patients. The use of combination therapy, although exhibiting a wide range within each category, was related to hospital type, with teaching and tertiary hospitals having a significantly higher use of combination therapy (teaching : non-teaching hospitals [$p < 0.0001$]; and primary : tertiary hospitals [$p < 0.0001$]).

Point-prevalence surveys are useful when time and resources do not allow for continuous surveillance. Repeated point-prevalence surveys within the same institution(s) can be used to monitor trends and effectiveness of antimicrobial-stewardship initiatives. Targets should be set as quality indicators

for the individual hospital(s) and effectiveness of any intervention monitored through repeated point-prevalence surveys. Spin-off initiatives, such as the Antibiotic Resistance and Prescribing in European Children, and the European Centre for Disease Prevention and Control point-prevalence survey on healthcare-associated infections and antimicrobial use, will utilize adapted versions of WebPPS, the point-prevalence survey software developed by ESAC. WebPPS will also be made available for non-commercial use to third parties. Interest has been shown from three continents outside Europe, namely North America, Australia and Africa.

1. Introduction

Antimicrobial resistance is a major public health problem because antimicrobial agents are unlike any other drug classes: their use has consequences both for the patient and the whole community. Therefore, surveillance systems of antimicrobial consumption and antimicrobial resistance are essential prerequisites for targeted interventions to cope with the problem of antibacterial resistance. Surveillance of antimicrobial consumption at the patient level, ideally through monitoring electronic prescribing in hospitals, can identify specific inappropriate use. Apart from changes in prescribing trends over time, point-prevalence surveys (PPSs) can also identify targets for quality improvement for particular clinical departments.[1] In the absence of continuous surveillance, repeated PPSs are a practical tool that can be utilized to measure the effectiveness of any change implemented in response to indicators identified during previous surveys.[2]

The European Surveillance of Antimicrobial Consumption (ESAC) project started as a pilot phase between 2001 and 2004 (ESAC-1: contract SI2.325736 [52001CVG4-016] by the Directorate General for Health and Consumer Policy [DG SANCO] of the European Commission [project 2001/SID/136]). Currently, all 27 EU member states and an additional seven countries (i.e. a total of 34 nations) participate in ESAC, which is coordinated by the University of Antwerp, Antwerp, Belgium. Each country has a network of experts led by the lead national representative and national representatives for the respective subprojects, namely ambulatory care, nursing homes, socioeconomics and hospital care. This review concentrates exclusively on hospital care PPSs. The list of ESAC publications related to PPSs is shown in table I.[1,3-9] The hospital subproject and, consequently, PPSs commenced during the second phase of ESAC (ESAC-2: grant agreement 2003/211 by the DG SANCO of the European Commission). The first hospital ESAC PPS held in 2006[5] during ESAC-2 served as a pilot for the two larger scale hospital PPSs carried out during ESAC-3 (grant agreement GRANT/2007/001 and specific agreement ECD.1018 by the European Centre for Disease Prevention and Control [ECDC]) in 2008 and 2009, respectively.

1.1 Why European Surveillance of Antimicrobial Consumption (ESAC) Hospital Point-Prevalence Surveys?

Resistance to antimicrobials is increasing and the correlation between consumption of certain drug classes and resistance developing in certain pathogens has been documented.[10-16] ESAC PPSs gathered data on the amount and type of antimicrobials linked to the indications for use. The latter is the reason why these surveys are important in addition to the longitudinal consumption data collection at the hospital level.[17] The European Antimicrobial Resistance Surveillance System (EARSS),[18] which is now completely integrated into the ECDC and renamed the European Antimicrobial Resistance Surveillance Network (EARS-NET), simultaneously collects antimicrobial resistance data for invasive isolates of selected pathogens. Together, these two surveillance networks (ESAC and EARS-NET) provide a Pan-European

Table I. Published European Surveillance of Antimicrobial Consumption manuscripts related to point-prevalence surveys

Year	Citation details
2009[3]	Heginbothom M, Howe R. National Public Health Service for Wales report on point prevalence survey of antimicrobial prescribing in secondary care in Wales, 2008 [online]. Available from URL: http://www2.nphs.wales.nhs.uk:8080/WARPDocs.nsf/61c1e930f9121fd080256f2a004937ed/081e10fdd2def1c4802575ed0041b5c3/$FILE/All-Wales%20Antimicrobial%20PPS%202008%20report.pdf [Accessed 2010 Dec 30]
2009[4]	ESAC. Report on the point prevalence survey of antimicrobial prescriptions in European hospitals, 2008 [online]. Available from URL: http://www.esac.ua.ac.be/download.aspx?c=*ESAC2&n=50297&ct=50294&e=50480 [Accessed 2010 Dec 30]
2009[5]	Ansari F, Erntell M, Goossens H, et al. The European Surveillance of Antimicrobial Consumption (ESAC) point-prevalence survey of antibacterial use in 20 European hospitals in 2006. Clin Infect Dis 2009 Nov; 49: 1496-504
2010[6]	Malcolm W, Cromwell T., on behalf of Information Workstream of Scottish Antimicrobial Prescribing Group. European Surveillance of Antimicrobial Consumption Point Prevalence Survey 2009 Scottish Hospitals Report, March 2010 [online]. Available from URL: http://www.scottishmedicines.org.uk/files/ESAC_report_final_060510.pdf [Accessed 2010 Dec 30]
2010[7]	Aldeyab M, Kearney M, McElnay J, et al. A point prevalence survey of antibiotic prescriptions: benchmarking and patterns of use. Br J Clin Pharmacol 2011 Feb; 71 (2): 293-6
2010[8]	ESAC. Report on point prevalence survey of antimicrobial prescribing in European Hospitals, 2009 [online]. Available from URL: http://www.esac.ua.ac.be/download.aspx?c=*ESAC2&n=50297&ct=50294&e=50483 [Accessed 2010 Dec 30]
2010[9]	Amadeo B, Zarb P, Muller A, et al. ESAC point prevalence survey 2008: paediatric antimicrobial prescribing in 32 hospitals of 21 European countries. J Antimicrob Chemother 2010; 65: 2247-2252
2011[1]	Zarb P, Amadeo B, Muller A, et al. Identification of targets for quality improvement in antimicrobial prescribing: the web-based ESAC Point Prevalence Survey 2009. J Antimicrob Chemother 2011 Feb; 66 (2): 443-9

picture of the current and emerging trends in antimicrobial consumption and resistance. The EARSS and ESAC had agreed on sharing data for hospitals participating in both networks. These data are currently being processed for approximately 13 hospitals.

PPSs have been used to assess the prevalence of various hospital indicators (e.g. wounds,[19] psychiatric treatment,[20] appropriateness of admission[21] and infections[22-26]) for almost 4 decades.[27] Various PPSs on hospital antimicrobial consumption have also been published in the last 2 decades.[28-36] However, methodologies varied greatly with regard to population, aims and details, making comparisons and benchmarking difficult. The initial attempt at standardizing the methodology across Europe was in the first ESAC PPS.[5]

1.2 Point-Prevalence Survey Objectives

The aims of the first ESAC PPS (2006) were primarily to (i) standardize a PPS methodology for routine use; (ii) assemble data about the prescribed daily doses of antimicrobials and determine the relationship with WHO-defined daily doses; and (iii) identify targets for quality improvement.[5] Follow-up PPSs intended to roll out this methodology for use on a large scale using a dedicated web-based tool for the submission of data directly to a host server. The overall objective of these PPSs was to identify targets for quality improvement that act as quality indicators of antimicrobial consumption in the hospital care sector.

The purpose of this review is to summarize the various aspects involved in the process of (i) organizing a European PPS; (ii) standardizing data collection methodology; (iii) development of a dedicated web-based tool; and (iv) the usefulness of such a methodology in identifying targets for quality improvement.

2. Methods

2.1 Hospitals

ESAC hospital PPS methodology was developed during the first hospital care subproject in ESAC-2. The pilot PPS (2006) enrolled a single hospital from each of the 20 participating countries.[5] These hospitals were often the institutions where the national representatives worked. During the ESAC-3 launch meeting in November 2007, the lead national representatives were asked to identify two hospitals (aiming at a total of

50 hospitals) able to provide the set of data for the longitudinal survey and participate in the 2008 PPS by March 2008. At the 2008 Annual Meeting, the lead national representatives were asked to identify as many hospitals as possible to participate in the 2009 PPS by March 2009. The 2009 ESAC PPS remains the largest hospital PPS to date. In England and Scotland (from the UK), and Ireland and Belgium, respective national antimicrobial societies were very influential in increasing the participation for the 2009 PPS from these countries. None of these three surveys were intended for benchmarking at the national or European level as the sample of hospitals were never intended to be representative of the participating countries.

2.2 Data Collection and Web-Based Software

For the 2006 PPS, the method established by the Swedish Strategic Programme against Antibiotic Resistance (STRAMA) was adapted for ESAC. The STRAMA web-based data collection included key information about antimicrobials (dose/route of administration), indication (prophylaxis/treatment) and patient characteristics (age and sex) that facilitated data interpretation. However, some data gathered by STRAMA in Sweden was not feasible for some participating countries. Therefore, in order to have a uniform database across the 20 participating hospitals, some fields were eliminated for the ESAC survey of 2006 even though an adapted version of their software, translated in English, was used. For the second and third PPSs (2008 and 2009), a web-based tool was developed in-house by ESAC (WebPPS).[1] Both STRAMA (2006) and WebPPS (2008, 2009) software were customized for each hospital's ward and antimicrobial list.

In all three PPSs, data were collected from patient notes (including both physical and electronic versions of treatment charts, laboratory results and any form of official documentation). If not enough information was documented, the surveyors could gather additional information from resident healthcare professionals without discussing appropriateness of treatment. For the first survey, a training meeting was held during the 16th European Congress of Clinical Microbiology and Infectious Disease held in Nice, France (2006), as all participants attended the congress. The training session reviewed pilot data from each of the participating hospitals for training in data entry, to ensure consistency of interpretation of indications for antibacterial use. For the subsequent two surveys, the national representatives discussed issues identified in the first survey and agreed on the solutions provided. The same national representatives were involved in the data collection and training of other staff from the participating hospitals. The surveyors were clinical healthcare professionals experienced in accessing patient files, and were often clinical pharmacists, clinical microbiologists, infection control professionals or infectious disease specialists.

Each survey was carried out within a maximum of 2 calendar weeks, preferably a single day, depending on the number of beds and personnel available to carry out the survey. The three PPSs were carried out during the second quarter of the respective year (2006, 2008 and 2009), with the only exception being in 2009 since the Belgian hospitals carried out the survey in November. All beds in each department had to be surveyed in 1 day. Since information on surgical prophylaxis for the previous 24-hour period was being audited, surgical wards were preferably surveyed on Tuesday, Wednesday or Thursday in order to avoid weekends. In surgical patients, the duration of prophylaxis was recorded as either one dose, 1 day or >1 day, and only if the patient received prophylactic antimicrobials during the preceding 24 hours. All non-surgical wards could be surveyed any day of the week. The denominator inclusion criteria encompassed all patients admitted in the hospital (or department) by 8:00am on the day of survey. Likewise, the details of prophylaxis or treatment of patients on antimicrobials at 8:00am (numerator) were documented. Treatment intent was classified by the anatomical diagnostic site whenever this information was either documented or obtainable from ward healthcare professionals.

The WHO Anatomical Therapeutic Chemical Classification of drugs and respective defined daily doses were used throughout ESAC PPSs.

The antimicrobial classes included all systemic antibacterials (J01), rifampicin from J04AB, oral vancomycin from A07AA, and oral and rectal metronidazole from P01AB. The prescribed doses and dosing intervals were documented.

The experience of the first two surveys identified a lack of availability of information about whether an appropriate specimen was taken for culture and sensitivity. Thus, since it was important, or at least desirable, to have consistent data from all participating hospitals, this parameter was replaced by adherence to guidelines for the final survey. Guideline compliance was assessed by the hospital surveyors based on the respective hospital guidelines. In cases where the specific indication for which the antimicrobial was prescribed was not included in the hospital's guidelines, the surveyors decided based on their own expertise (e.g. clinical microbiologists and infectious disease physicians), consulted the hospital experts or forwarded the question to the ESAC management team for an answer.

3. Results

3.1 Overview of Participation in the Three Point-Prevalence Surveys

In the 2006 PPS, 20 countries participated with one hospital each. Amongst these countries, three dropped out for the 2008 PPS, but an additional 14 countries participated with a total of 50 hospitals from 31 countries. The number of hospitals in the 2009 PPS increased to 172; however, the number of countries decreased by 6 to 25. The details of participating countries are shown in table II.

3.2 Demographics and Indications

The demographics for the three PPSs were very comparable to analogous proportions of treated patients, sex and paediatric patients as shown in table III. The table also shows that despite the fact that the number of patients increased more than 6-fold from 2006 to 2009 (11 571–73 060), the proportions of the different indications did not demonstrate any significant changes.

Table II. Countries participating in the respective European Surveillance of Antimicrobial Consumption point-prevalence surveys

Country-code	2006	2008	2009
Austria-AT	1	2	7
Belgium-BE	1	2	19
Bulgaria-BG		1	1
Switzerland-CH		1	1
Cyprus-CY		2	2
Czech Republic-CZ	1	3	4
Germany-DE[a]		1	
Denmark-DK	1	1	2
Estonia-EE	1	2	3
England-EN[b]	1	3	45
Spain-ES		1	2
Finland-FI[c]	1	1	
France-FR	1	1	3
Greece-GR[c]	1	1	
Croatia-HR	1	2	3
Hungary-HU		1	1
Ireland-IE		2	21
Israel-IL		1	1
Italy-IT		3	2
Lithuania-LT[c]	1	2	
Luxembourg-LU[a]		1	
Latvia-LV	1	2	2
Malta-MT	1	1	1
Northern Ireland-NI[b]	1	1	4
The Netherlands-NL[d]	1		
Norway-NO	1	2	2
Poland-PL[d]	1		
Portugal-PT		2	2
Russian Federation-RU		2	3
Scotland-SC[b]	1	2	31
Sweden-SE[d]	1		
Slovenia-SI	1	1	5
Turkey-TR[a]		1	
Wales-WL[b]		2	5
Total countries	**20**	**31**	**25**
Total hospitals	**20**	**50**	**172**
Total teaching hospitals	**13**	**33**	**76**

a Germany, Luxembourg and Turkey only participated in 2008.

b England, Northern Ireland, Scotland and Wales are different administrations of the UK, which is a single EU Member State.

c Finland, Greece and Lithuania only participated in 2006 and 2008.

d The Netherlands, Poland and Sweden only participated in 2006.

Table III. Results overview of the respective European Surveillance of Antimicrobial Consumption point-prevalence survey

	2006	2008	2009
Demographics			
No. of patients	11 571	25 993	73 060
On antimicrobials (%)	30.1	31.0	29.0
Average prescriptions/patient	1.37	1.36	1.40
Females (%)	47.5	45.1	46.6
Paediatric patients (%)	10.7	10.4	7.5
Indications (%)			
Diagnosis site respiratory (most common)	24.1	21.3	27.2
Community-acquired infection	48.4	46.1	48.9
Hospital-acquired infection	30.0	29.0	30.7
Surgical prophylaxis	15.0	15.9	12.8
Medical prophylaxis	6.7	8.8	6.7
Indicators (%)			
Reason in notes	64.4	67.7	59.4
Surgical prophylaxis >1 d	57.3	68.8	53.0
Sample for culture and sensitivity[a]	44.2	46.8	NA
Guideline compliance[b]	NA	NA	50.8

a Sample for culture and sensitivity was dropped for the final point-prevalence survey in 2009 because such data were more difficult to collect.

b Guideline compliance was introduced in 2009 replacing the sample for culture and sensitivity.

NA = not applicable.

3.3 Overview of ESAC Point-Prevalence Survey 2009 by Hospital Classification

Two independent types of self-declared classifications were used in ESAC PPSs. Hospitals were grouped into 'teaching' and 'non-teaching' institutes. Hospitals that either had undergraduate academic students and/or postgraduate trainees were classified as 'teaching' hospitals. A parallel categorization grouped the hospitals into 'primary', 'secondary', 'tertiary' and specialized centres. The latter categorization is not applied in all countries; therefore, hospitals were classified based on whether they act as primary point-of-care (primary) or district referral centres to primary hospitals (secondary) with the possibility to refer to expert regional centres (tertiary). In addition, hospitals highly specialized in one particular area (e.g. infectious diseases) were classified accordingly as 'specialized' hospitals. The large number of participating hospitals in the 2009 PPS allowed for analysis by the previously mentioned categories. Data showed great differences in hospitals from any category in the use of combination therapy (figure 1). The difference between teaching and non-teaching hospitals was highly significant ($p < 0.0001$). The difference in the proportion of combination therapy was also highly significant between primary and tertiary hospitals ($p < 0.0001$), and significant ($p < 0.01$) between primary and secondary hospitals (table IV).

4. Discussion

There is no known ideal standardized method for how to measure trends of antimicrobial use.[5] However, PPSs are useful when time and resources do not allow for continuous/longitudinal monitoring to measure incidence. Since prevalence is approximately equal to incidence multiplied by duration, there is a tendency for prevalence surveys to overestimate incidence. This is more evident when monitoring episodes of healthcare-associated infections rather than antimicrobial use. Estimation of the incidence or prevalence of healthcare-associated infections was not an objective of the ESAC PPSs. Overestimation is particularly pertinent to duration of surgical prophylaxis, one of the most important targets for quality improvement identified by ESAC PPSs. There is the likelihood of an overestimation of surgical prophylaxis prolonged beyond 24 hours. However, this does not decrease the importance of this indicator since no surgical prophylaxis should be extended beyond the 24-hour period of cover.[37,38] Thus, if a hospital or country sets targets to decrease the proportion of cases with prolonged surgical prophylaxis (e.g. to <5%), this can easily be monitored using the ESAC PPS methodology. This is also applicable to another target identified in ESAC PPSs and also other PPSs (i.e. documentation of the reason for starting antimicrobials in patient notes) which according to the Scottish Antimicrobial Prescribing Group should be >95%,[6] although it was much lower for ESAC PPSs (table III).[1,5] In fact, repeated PPSs using a standardized methodology within the same institution can be used both to

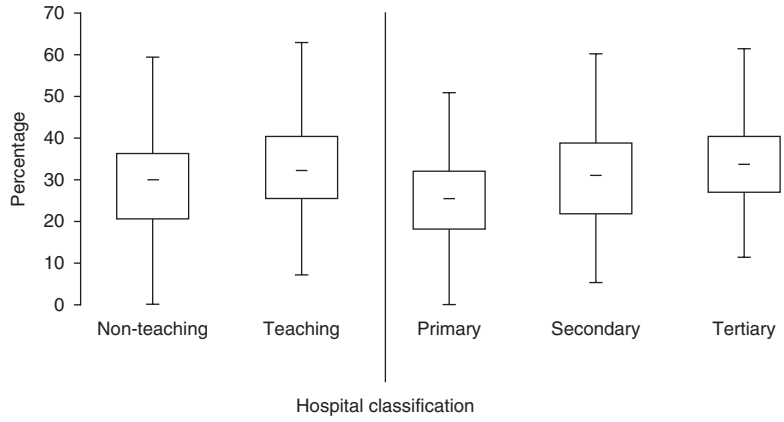

Fig. 1. Box and whisker plot of combination therapy by two types of hospital classifications: teaching and non-teaching; and primary, secondary and tertiary.

demonstrate trends of use as well as to determine the effectiveness of any antimicrobial stewardship intervention.[2,34] The web-based method for collection of PPS data with automatic reporting was implemented successfully in all three ESAC PPSs.[1,5,9]

Since these PPSs were carried out across Europe, local authorities should avoid the pitfall of ranking hospitals exclusively by prevalence of antimicrobial use, especially because most of the disparity is either due to chance or evident differences in case mix.[5,39,40] Furthermore, ranking is an extremely unpredictable method for comparing the performance of hospitals.[41] Indeed, results from the first ESAC PPS of 2006 showed that only 8 of 20 hospitals could be reliably ranked in the top (high consumer) or bottom (low consumer) half based only on antimicrobial use.[5]

In selecting the data fields to collect, it is important to reach an acceptable conciliation between an ideal situation where a lot of detail is obtained and feasibility of data collection. This became evident to ESAC prior to the first PPS of 2006. In fact, during a preparatory meeting, it was decided to include less data than in the Swedish PPS on which the ESAC methodology was developed because some information was difficult for some countries to obtain.[5] This means that the wider the spectrum of participants in a PPS, the fewer the data are that can be collected in a consistent way to enable hospitals from different healthcare systems to be compared. In contrast, the methodology can be adapted to collect more detail if data are being collected from one healthcare system using a rather standardized documentation and service.

The majority of antimicrobials are prescribed in the community and hospital care consumption accounts for only 5–10% of total exposure.[42] It would, therefore, have been expected that hospitals use higher doses than the defined daily dose, which is an absolute 'average' taking into account all use. However, an unexpected finding of ESAC PPSs was that the WHO-defined daily doses could be either higher or lower than the actual prescribed daily doses, irrespective of route of administration.[5] This could be an issue for hospitals that change prescribing trends from a drug with a higher prescribed daily dose than defined daily dose to a drug whose defined daily dose is higher than prescribed daily dose, as this could seem to be a decrease in consumption, whilst in practice the proportion of treated patients could remain unchanged. If there is a switch in the opposite direction, it would seem to be an increase in consumption that is not reflected in the number of treated patients. This further highlights the importance of not ranking hospitals as they might use different antimicrobials with different defined daily dose to prescribed daily dose ratios. However, the defined daily dose methodology is the only universally recognized standardized method

Table IV. Overview of European Surveillance of Antimicrobial Consumption point-prevalence survey 2009 by hospital classification

Prescriptions	Teaching (n = 76)	Non-teaching (n = 96)	Specialty (n = 5)	Primary (n = 21)	Secondary (n = 89)	Tertiary (n = 57)
Combination therapy (%)	30.4	33.2	33.52	27.37	31.09	33.55
Different antimicrobials	96	93	44	68	90	101
Different antimicrobial combinations	1200	754	104	207	720	1104
Different antimicrobials (including combinations)	1306	847	148	275	810	1205
Top ten antimicrobial (ATC code) [% prescriptions]	Co-amoxiclav (J01CR02) [18.1]	Co-amoxiclav (J01CR02) [15.2]	Co-amoxiclav (J01CR02) [14.4]	Co-amoxiclav (J01CR02) [22.2]	Co-amoxiclav (J01CR02) [17.4]	Co-amoxiclav (J01CR02) [14.8]
	Piperacillin/tazobactam (J01CR05) [5.9]	Ciprofloxacin (J01MA02) [5.7]	Ciprofloxacin (J01MA02) [6.3]	Piperacillin/tazobactam (J01CR05) [6.0]	Piperacillin/tazobactam (J01CR05) [6.0]	Ciprofloxacin (J01MA02) [6.4]
	Ciprofloxacin (J01MA02) [5.2]	Piperacillin/tazobactam (J01CR05) [5.5]	Ceftriaxone (J01DD04) [5.9]	Ciprofloxacin (J01MA02) [5.1]	Trimethoprim (J01EA01) [4.7]	Piperacillin/tazobactam (J01CR05) [5.5]
	Trimethoprim (J01EA01) [4.0]	Cefuroxime (J01DC02) [4.3]	Trimethoprim (J01EA01) [4.7]	Trimethoprim (J01EA01) [3.9]	Ciprofloxacin (J01MA02) [4.6]	Cefuroxime (J01DC02) [4.5]
	Cefuroxime (J01DC02) [3.3]	Amoxicillin (J01CA04) [2.8]	Cefuroxime (J01DC02) [4.7]	Flucloxacillin (J01CF05) [3.7]	Amoxicillin (J01CA04) [3.5]	Ceftriaxone (J01DD04) [2.9]
	Flucloxacillin (J01CF05) [2.8]	Trimethoprim (J01EA01) [2.6]	Flucloxacillin (J01CF05) [4.0]	Cefuroxime (J01DC02) [3.1]	Cefuroxime (J01DC02) [3.1]	Cefazolin (J01DB04) [2.4]
	Amoxicillin (J01CA04) [2.8]	Flucloxacillin (J01CF05) [2.6]	Cefuroxime (J01DC02), metronidazole (J01XD01) [3.6]	Amoxicillin9 (J01CA04) [3.0]	Flucloxacillin (J01CF05) [3.0]	Flucloxacillin (J01CF05) [2.2]
	Cefazolin (J01DB04) [2.6]	Ceftriaxone (J01DD04) [2.5]	Amoxicillin (J01CA04) [2.7]	Cefazolin (J01DB04) [2.7]	Co-amoxiclav (J01CR02), clarithromycin (J01FA09) [2.1]	Amoxicillin (J01CA04) [2.1],
	Ceftriaxone (J01DD04) [2.0]	Cefazolin (J01DB04) [1.9]	Piperacillin/tazobactam (J01CR05) [2.3]	Imipenem (J01DH51) [1.7]	Cefazolin (J01DB04) [1.9]	Meropenem (J01DH02) [1.9]
	Co-amoxiclav (J01CR02), clarithromycin (J01FA09) [1.7]	Meropenem (J01DH02) [1.8]	Co-amoxiclav (J01CR02), clarithromycin (J01FA09) [1.9]	Levofloxacin (J01MA12) [1.6]	Clarithromycin (J01FA09) [1.9]	Trimethoprim (J01EA01) [1.7]
Top four indication sites (%)	RESP (26.6)	RESP (25.7)	RESP (24.6)	RESP (24.9)	RESP (26.4)	RESP (26)
	SSTBJ (20)	SSTBJ (17.4)	SSTBJ (18.8)	SSTBJ (17.7)	SSTBJ (19.9)	SSTBJ (17.4)
	UT (17.7)	GI (16.2)	GI (17.4)	GI (17.1)	UT (18.4)	GI (15.8)
	GI (15.9)	UT (15.4)	UT (15.3)	UT (16.9)	GI (16.1)	UT (14.5)

ATC = Anatomical Therapeutic Chemical; **Co-amoxiclav** = amoxicillin/clavulanic acid; **GI** = gastrointestinal tract; **RESP** = respiratory tract; **SSTBJ** = skin soft tissue bone and joint; **UT** = urinary tract.

of measuring drug consumption and, in spite of its limitations, it is still very useful.

A wide range in the proportion of treated patients was identified amongst the different hospitals both in the ESAC PPSs as well as other studies from Europe, even in hospitals from one country.[5,34] However, the appropriateness or compliance with guidelines was not assessed until the 2009 PPS, which was found to be 62%.[1] This is perfectly in line with the findings of a Dutch publication of repeated PPSs.[2] Despite the wide range of values for each characteristic from the different hospitals, the overall values were consistent throughout the three ESAC PPSs, as can be seen in table III. Table IV shows significant differences in the use of combination therapy for different types of hospitals but minimal differences, if any, in the most used antimicrobial agents and most commonly identified diagnosis sites, with mainly just a reshuffle in ranking order. This statement holds true both when comparing teaching versus non-teaching and when comparing primary with secondary and/or tertiary hospitals. This indicates that this standard methodology consistently gives reliable results and that combination therapy must be assessed accordingly.

There is no 'one-size-fits-all' consensus on the type of data collected and the frequency of PPSs. The wider the range of participating hospitals, the less frequently the survey can be carried out. In addition, the number of data fields collected also has to be minimized in order to improve feasibility and enhance participation. In such a scenario, probably a yearly survey could be appropriate as long as this allows time for the central management to analyse and report the data. The use of the WebPPS software would facilitate matters. On the other hand, repeated PPSs within a single hospital, or department within a hospital, could be carried out on a more frequent basis, possibly monthly or quarterly. In the latter case, the survey could only collect data to monitor targeted interventions (e.g. the documentation of prescribing indication within patients' notes).

ESAC will shift in its entirety to the ECDC at the end of June 2011. The ECDC will continue to collect core national data on antimicrobial consumption only within member states. The ESAC WebPPS has recently been adapted for surveillance of both antimicrobial use and healthcare-associated infections in a combined PPS that was piloted in the third quarter of 2010.[43] In addition, another European project, Antibiotic Resistance and Prescribing in European Children, will utilize a different adapted version of WebPPS.

The University of Antwerp is looking forward to providing the software to individual hospitals or health systems that agree with the stipulated terms and conditions. The agreement states that (i) the software cannot be used for commercial purposes; (ii) the software cannot be redistributed by the clients; (iii) the WebPPS needs to be installed on the clients' server; (iv) since there is no funding for the upkeep of the WebPPS, the university cannot provide a central helpdesk; and (v) in case changes need to be made to the software, these must pass through, and preferably be developed by, the University of Antwerp as the actual software code will not be provided.

Finally, it is appropriate to conclude that in the absence of continuous surveillance, which is more accurate but more demanding on human resources, PPS methodology is an excellent surveillance method. Furthermore, the WebPPS tool developed by ESAC is a dynamic tool, suitable for use in data entry and feedback to participating institutions. WebPPS will be made available for non-commercial use under license to any interested parties. Interest has been shown from three different continents outside Europe, namely North America, Australia and Africa.

Acknowledgements

Funding: ESAC received three grants from EU funds. ESAC would like to thank the Directorate General for Health and Consumer Policy of the European Commission for ESAC-1 (contract SI2.325736 [52001CVG4-016]) and ESAC-2 (agreement 2003/211). ESAC would also like to thank the European Centre for Disease Prevention and Control for ESAC-3 (grant agreement GRANT/2007/001 and specific agreement ECD.1018). Special thanks also go to all National Networks coordinated by the respective lead national representatives (who might have changed through the years), especially the Hospital Care subproject national representatives. The authors have no conflicts of interest to declare.

References

1. Zarb P, Amadeo B, Muller A, et al. Identification of targets for quality improvement in antimicrobial prescribing: the web-based ESAC Point Prevalence Survey 2009. J Antimicrob Chemother 2011 Feb; 66 (2): 443-9
2. Willemsen I, Groenhuijzen A, Bogaers D, et al. Appropriateness of antimicrobial therapy measured by repeated prevalence surveys. Antimicrob Agents Chemother 2007 Mar; 51: 864-7
3. Heginbothom M, Howe R. National Public Health Service for Wales report on point prevalence survey of antimicrobial prescribing in secondary care in Wales, 2008 [online]. Available from URL: http://www2.nphs.wales.nhs.uk:8080/WARPDocs.nsf/61c1e930f9121fd080256f2a004937ed/081e10fdd2def1c4802575ed0041b5c3/$FILE/All-Wales%20Antimicrobial%20PPS%202008%20report.pdf [Accessed 2010 Dec 30]
4. ESAC. Report on the point prevalence survey of antimicrobial prescriptions in European hospitals, 2008 [online]. Available from URL: http://www.esac.ua.ac.be/download.aspx?c=*ESAC2&n=50297&ct=50294&e=50480 [Accessed 2010 Dec 30]
5. Ansari F, Erntell M, Goossens H, et al. The European Surveillance of Antimicrobial Consumption (ESAC) point-prevalence survey of antibacterial use in 20 European hospitals in 2006. Clin Infect Dis 2009 Nov; 49: 1496-504
6. Malcolm W, Cromwell T, on behalf of Information Workstream of Scottish Antimicrobial Prescribing Group (SAPG). European Surveillance of Antimicrobial Consumption point prevalence survey 2009 Scottish Hospitals Report, May 2010 [online]. Available from URL: http://www.scottishmedicines.org.uk/files/ESAC_report_final_060510.pdf [Accessed 2010 Dec 30]
7. Aldeyab M, Kearney M, McElnay J, et al. A point prevalence survey of antibiotic prescriptions: benchmarking and patterns of use. Br J Clin Pharmacol 2011 Feb; 71 (2): 293-6
8. ESAC. Report on point prevalence survey of antimicrobial prescribing in European hospitals, 2009 [online]. Available from URL: http://www.esac.ua.ac.be/download.aspx?c=*ESAC2&n=50297&ct=50294&e=50483 [Accessed 2010 Dec 30]
9. Amadeo B, Zarb P, Muller A, et al. European surveillance of antibiotic consumption (ESAC) point prevalence survey 2008: paediatric antimicrobial prescribing in 32 hospitals of 21 European countries. J Antimicrob Chemother 2010 Oct; 65: 2247-52
10. van de Sande-Bruinsma N, Grundmann H, Verloo D, et al. Antimicrobial drug use and resistance in Europe. Emerg Infect Dis 2008 Nov; 14: 1722-30
11. Goossens H, Ferech M, Vander Stichele R, et al. Outpatient antibiotic use in Europe and association with resistance: a cross-national database study. Lancet 2005 Feb; 365: 579-87
12. Borg MA, Zarb P, Scicluna EA, et al. Antibiotic consumption as a driver for resistance in Staphylococcus aureus and Escherichia coli within a developing region. Am J Infect Control 2010 Apr; 38: 212-6
13. Jacoby TS, Kuchenbecker RS, Dos Santos RP, et al. Impact of hospital-wide infection rate, invasive procedures use and antimicrobial consumption on bacterial resistance inside an intensive care unit. J Hosp Infect 2010 May; 75: 23-7
14. Goossens H. Antibiotic consumption and link to resistance. Clin Microbiol Infect 2009 Apr; 15 Suppl. 3: 12-5
15. Lai CC, Wang CY, Chu CC, et al. Correlation between antimicrobial consumption and resistance among Staphylococcus aureus and enterococci causing healthcare-associated infections at a university hospital in Taiwan from 2000 to 2009. Eur J Clin Microbiol Infect Dis 2011 Feb; 30 (2): 265-71
16. Metz-Gercek S, Maieron A, Strauss R, et al. Ten years of antibiotic consumption in ambulatory care: trends in prescribing practice and antibiotic resistance in Austria. BMC Infect Dis 2009; 9: 61
17. Ansari F, Molana H, Goossens H, et al. Development of standardized methods for analysis of changes in antibacterial use in hospitals from 18 European countries: the European surveillance of antimicrobial consumption (ESAC) longitudinal survey, 2000-06. J Antimicrob Chemother 2010 Dec; 65: 2685-91
18. Bronzwaer S, Goettsch W, Olsson-Liljequist B, et al. European Antimicrobial Resistance Surveillance System (EARSS): objectives and organisation. Euro Surveill 1999; 4 (4): pii=66 [online]. Available from URL: http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=66 [Accessed 2010 Dec 30]
19. Gruen RL, Chang S, MacLellan DG. The point prevalence of wounds in a teaching hospital. Aust NZ J Surg 1997 Oct; 67: 686-8
20. Burvill PW, Finlay-Jones RA. A point prevalence study of outpatients and inpatients in the mental health services, general hospital psychiatric units, and under private psychiatrists in Perth, Western Australia. Aust NZ J Psychiatry 1977 Mar; 11: 45-51
21. Ochoa Calvo P, García-Arilla Calvo E. Inappropriate hospital admission and stay according to the appropriateness evaluation protocol: study of point prevalence in a geriatric department [letter]. Med Clin (Barc) 1997 Jun; 109: 195
22. Starakis I, Marangos M, Gikas A, et al. Repeated point prevalence survey of nosocomial infections in a Greek university hospital. J Chemother 2002 Jun; 14: 272-8
23. Leblebicioglu H, Esen S. Hospital-acquired urinary tract infections in Turkey: a nationwide multicenter point prevalence study. J Hosp Infect 2003 Mar; 53: 207-10
24. Balkhy HH, Cunningham G, Chew FK, et al. Hospital- and community-acquired infections: a point prevalence and risk factors survey in a tertiary care center in Saudi Arabia. Int J Infect Dis 2006 Jul; 10: 326-33
25. Ritchie S, Jowitt D, Roberts S. The Auckland city hospital device point prevalence survey 2005: utilisation and infectious complications of intravascular and urinary devices. NZ Med J 2007; 120: U2683
26. Faria S, Sodano L, Dauri M, et al. First point prevalence survey of nosocomial infections in the intensive care units of a tertiary care hospital in Albania. J Hosp Infect 2008 May; 69: 95-7
27. McKechnie AA. A point prevalence study of a long term hospital population. Health Bull (Edinb) 1972 Oct; 30: 250-8
28. Cooke DM, Salter AJ, Phillips I. The impact of antibiotic policy on prescribing in a London teaching hospital: a one-day prevalence survey as an indicator of antibiotic use. J Antimicrob Chemother 1983 May; 11: 447-53
29. Berild D, Ringertz SH, Lelek M. Appropriate antibiotic use according to diagnoses and bacteriological findings: report

of 12 point-prevalence studies on antibiotic use in a university hospital. Scand J Infect Dis 2002; 34: 56-60

30. Usluer G, Ozgunes I, Leblebicioglu H. A multicenter point-prevalence study: antimicrobial prescription frequencies in hospitalized patients in Turkey. Ann Clin Microbiol Antimicrob 2005; 4: 16
31. Ufer M, Radosević N, Vogt A, et al. Antimicrobial drug use in hospitalised paediatric patients: a cross-national comparison between Germany and Croatia. Pharmacoepidemiol Drug Saf 2005 Oct; 14: 735-9
32. Seaton RA, Nathwani D, Burton P, et al. Point prevalence survey of antibiotic use in Scottish hospitals utilising the Glasgow antimicrobial audit tool (GAAT). Int J Antimicrob Agents 2007 Jun; 29: 693-9
33. Hajdu A, Samodova OV, Carlsson TR, 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 Aug; 66: 378-84
34. Diminņa E, Kūla M, Caune U, et al. Repeated prevalence studies on antibiotic use in Latvia, 2003-2007. Euro Surveill 2009; 14 (33): pii=19307 [online]. Available from URL: http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=19307 [Accessed 2010 Nov 03]
35. Ciofi Degli Atti ML, Raponi M, Tozzi AE, et al. Point prevalence study of antibiotic use in a paediatric hospital in Italy. Euro Surveill 2008; 13 (41): pii=19003 [online]. Available from URL: http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=19003 [Accessed 2010 Dec 30]
36. Ang L, Laskar R, Gray JW. A point prevalence study of infection and antimicrobial use at a UK children's hospital. J Hosp Infect 2008 Apr; 68: 372-4
37. Harbarth S, Samore MH, Lichtenberg D, et al. Prolonged antibiotic prophylaxis after cardiovascular surgery and its effect on surgical site infections and antimicrobial resistance. Circulation 2000 Jun; 101: 2916-21
38. Scottish Intercollegiate Guidelines Network (SIGN). Sign 104: antibiotic prophylaxis in surgery. A national clinical guideline (July 2008) [online]. Available from URL: http://www.sign.ac.uk/pdf/sign104.pdf [Accessed 2010 Nov 25]
39. Kuster SP, Ruef C, Bollinger AK, et al. Correlation between case mix index and antibiotic use in hospitals. J Antimicrob Chemother 2008 Oct; 62: 837-42
40. Kuster SP, Ruef C, Ledergerber B, et al. Quantitative antibiotic use in hospitals: comparison of measurements, literature review, and recommendations for a standard of reporting. Infection 2008 Dec; 36: 549-59
41. Spiegelhalter D. Ranking institutions. J Thorac Cardiovasc Surg 2003 May; 125: 1171-3; author reply 1173
42. Vander Stichele RH, Elseviers MM, Ferech M, et al. Hospital consumption of antibiotics in 15 European countries: results of the ESAC retrospective data collection (1997-2002). J Antimicrob Chemother 2006 Jul; 58: 159-67
43. Watson R. A quarter of patients in some European hospitals acquire infections [letter]. BMJ 2010; 341: c6700

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