Do medical students feel prepared to prescribe antibiotics responsibly? Results from a cross-sectional survey in 29 European countries

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Background: In an era of antibiotic resistance, medical students must be prepared to prescribe antibiotics responsibly.

Objectives: To assess self-reported preparedness among final-year medical students at European universities, using a comprehensive set of topics related to prudent antibiotic use.

Methods: We conducted a cross-sectional, multicentre, web-based survey. All medical-degree students in their final year of studies at European universities were eligible to participate. A preparedness score was calculated for each student and mean scores were compared at medical school and country levels. Comparisons were made with national-level data on resistance among four common bacterial pathogens.

Results: In total, 7328 responses were included from 179/296 eligible medical schools in 29/29 countries. Students felt at least sufficiently prepared on a mean of 71.2% of topics assessed, ranging from 54.8% (Portugal) to 84.8% (Latvia). The proportion of students wanting more education on prudent antibiotic use or general antibiotic use ranged from 20.3% (Sweden) to 94.3% (Slovakia), with a mean of 66.1%, and was strongly inversely correlated with preparedness scores (Spearman’s $p = -0.72, n = 29, P < 0.001$). Higher prevalence rates of antibiotic-non-susceptible bacteria were associated with lower preparedness scores and higher self-reported needs for further education ($P < 0.01$).

Conclusions: Most final-year European medical students feel they still need more education on antibiotic use for their future practice as junior doctors. Patterns of preparedness on specific topics were identified, were highly consistent across countries, and correlated with both perceived need for further education and levels of antibiotic resistance among common bacteria.

Introduction

Most doctors prescribe medications on a daily basis throughout their careers, but, despite this, prescribing remains an activity for which junior doctors consistently feel underprepared. 1,2 Antibiotics are among the most common medications prescribed by junior doctors across all clinical disciplines, and are often prescribed without senior supervision or specialist input.

Medical schools are tasked with preparing tomorrow’s doctors to practice. Medical students are aware that antibiotics are misused in clinical practice and that misuse leads to antibiotic resistance, 3,4 they also perceive misuse as unethical. 5 As antibiotic resistance rates continue to rise globally, more is needed than awareness: medical schools must prepare students to prescribe antibiotics responsibly. The Global Action Plan on Antimicrobial Resistance highlighted the importance of training students on this, 6 and it is easier to shape behaviours at an earlier stage, rather than change established practices. 7

Previous studies have identified gaps in knowledge on responsible antibiotic use among medical students. 3,5,8 These studies have had important limitations, including assessing only a narrow range of topics and restricting participation to small numbers of...
medical schools or countries. The ESCMID Study Group for Antimicrobial stewardship (ESGAP) sought to assess how prepared final-year students at medical schools across Europe felt to prescribe antibiotics according to commonly accepted principles of prudent use. Using a comprehensive list of topics related to prudent antibiotic use, our objectives were: (i) to describe levels of self-reported preparedness on these different topics; (ii) to identify if any topics were consistently associated with high or low levels of preparedness; and (iii) to identify if certain countries consistently had higher or lower levels of preparedness among medical students. Our intention was to provide data to support targeted national and international improvement efforts in education for both undergraduates and junior doctors.

Methods

Study design and participants

We conducted a cross-sectional, multicentre, web-based survey at European medical schools to assess medical students’ self-reported preparedness on prudent antibiotic use. All medical students in their final year of studies on a medical-degree course at a university in Europe were eligible to participate. We defined Europe as the 28 EU Member States together with the four European Free Trade Association countries (Iceland, Liechtenstein, Norway and Switzerland); however, three countries (Cyprus, Liechtenstein and Luxembourg) did not have any medical schools with final-year students. We did not use any further exclusion criteria.

A coordinator was appointed for each country, typically an individual with an interest in antimicrobial stewardship and education, and many were ESGAP members. The coordinator managed communication with medical schools in their country throughout the study. First, the coordinator confirmed the list of schools in their country. Second, the coordinator wrote to as many schools as they could obtain contact details for, inviting them to participate and asking them to provide numbers of eligible students. Third, the coordinator sent invitation e-mails to medical schools to forward to their students. These e-mails were developed by the central study coordinator (O. J. D.) and coordinators were encouraged to translate and adapt them. Ideally, students received an invitation, followed by two reminders (after 2–4 and 8–14 weeks). The survey was also advertised in student lectures at some medical schools.

The self-administered survey was accessible on Survey Monkey from 20 January to 31 December 2015. Most countries participated in a first phase (January–August), but the survey remained open for a second phase (August–December) so that three countries with administrative delays could participate.

Questionnaire development

The survey instrument (available as Supplementary data at JAC Online) was developed by six international experts on antimicrobial stewardship through an informal consensual approach. It was based on an earlier study of curriculum coverage of common principles of prudent antibiotic use through an informal consensual approach. It was based on an earlier study of curriculum coverage of common principles of prudent antibiotic use in medical schools in Europe and was further informed by previous studies among medical students. The 47-item questionnaire included questions on demographics, self-reported preparedness on 27 curriculum topics on prudent antibiotic use (Table S1) using a 7-point Likert-type scale, perceptions of the usefulness of teaching methods and perceived need for further education. The questionnaire was developed in English, reviewed for language by coordinators in all countries and pilot-tested with eight students from France and the UK.

Statistical analyses

We excluded all responses in which participants had completed fewer than half of the questions on preparedness, and then excluded all responses from medical schools with fewer than five participating students. Answers to questions on preparedness on the 27 curriculum topics were condensed into two categories (4–7: at least sufficiently prepared; 1–3: insufficiently prepared). A medical school ‘topic preparedness’ score was created for each of the 27 curriculum topics by calculating the percentage of students at a medical school who felt at least sufficiently prepared on that topic. A country topic preparedness score was then calculated for each topic as the mean of the medical school topic preparedness scores for that topic.

Finally, the mean of the country topic preparedness scores was calculated for each topic, with all countries given equal weighting. Separately, ‘global preparedness’ scores were created as follows: individual global preparedness scores were calculated for each student, representing the percentage of the 27 topics in which a student felt at least sufficiently prepared. A medical school global preparedness score was calculated as the mean of the students’ individual preparedness scores within a medical school and then a country global preparedness score was calculated as the mean of the medical school global preparedness scores within a country. Finally, the mean of the country global preparedness scores was calculated, with all countries given equal weighting.

We assessed potential associations between preparedness and need for more education with country-level antibiotic susceptibility percentages and outpatient antibiotic use, by using data extracted for the year 2014 from the EARS-Net and ESAC-Net databases, respectively (see List S1). For each country, an antibiotic susceptibility score was created (as previously described) based on isolates from blood and CSF by summing the proportions (%) for MSSA, third-generation cephalosporin-susceptible Escherichia coli; fluoroquinolone-susceptible E. coli and macrolide-susceptible Streptococcus pneumoniae.

Comparisons between demographics and individual global preparedness scores were made using χ² tests, and with perceived needs for further education using χ² tests. Correlations were assessed using Spearman’s rank correlation, and the intraclass correlation coefficient (ICC) was used to assess between-country consistency in ranking of curriculum topics by preparedness levels. All analyses were performed in R, version 3.3.2, and statistical significance was set at P < 0.05.

Ethical approval

The study was approved by the Ethics Committee of Nancy University Hospital, France. Participation was voluntary, anonymous and without compensation.

Results

Participation

We received a total of 7430 responses from 214 of 296 eligible medical schools. Of these, 7328 responses were included in the analyses, from 179 medical schools (179/296, 60.5% of eligible schools) in 29/29 participating European countries. Data on eligible student numbers were available at 143/179 medical schools; at these schools the median response rate was 21.1% (IQR = 11.4–29.9%). The median response rate across countries was 20.0% (IQR = 12.0–27.2%). Response rates and participants per country are shown in Table S2. Respondents had a mean age of 25.0 years (SD = 2.6 years) and the majority were female (62.2%). Five percent of respondents would have preferred the survey in their own language rather than English.
Global preparedness scores and needs for more education

Country global preparedness scores, representing the proportion of curriculum topics that students felt at least sufficiently prepared on, ranged from 54.8% (Portugal) to 84.8% (Latvia), with a mean score across countries of 71.2% (SD 7.5%). Overall, 37.3% of students wanted more education on prudent use of antibiotics, 26.8% wanted more education on both prudent use of antibiotics and general use of antibiotics, 31.2% felt they did not need more education and 4.5% were unsure. There was wide variation between countries, with the proportion of students wanting more education ranging from 20.3% (Sweden) to 94.3% (Slovakia) and a mean across countries of 66.1% (SD 15.8%; Figure 1).

At the country level, perceived need for further education was strongly inversely correlated with global preparedness scores ($\rho = -0.72, n = 29, P < 0.001$; Figure S1) and a similar correlation existed across medical schools ($\rho = -0.74, n = 179, P < 0.001$; Figure S2). Global preparedness scores were marginally higher for male students (72.5% versus 70.0%, $P < 0.001$). Female students were more likely to express a need for further education (71.1% versus 64.8%, $P < 0.001$), as were students aged under 27 years (69.5% versus 64.2%, $P < 0.001$). There was a weak positive correlation between medical school response rate and global preparedness scores ($\rho = 0.16, P = 0.05$; Figure S3).

Preparedness and education need correlations with antibiotic use and antibiotic susceptibility

There was a correlation between national antibiotic susceptibility scores and country global preparedness scores ($\rho = 0.57, n = 28, P < 0.01$) as well as country mean needs for further education ($\rho = -0.57, n = 28, P < 0.01$), with higher prevalence rates of antibiotic-non-susceptible bacteria associated with lower levels of preparedness and higher needs for further education. Figure 2 shows these associations, with countries divided into tertiles based on their national antibiotic susceptibility score. There was no significant correlation between outpatient antibiotic consumption and country global preparedness scores or country mean needs for further education.

Preparedness in different curriculum topics

Students reported varying levels of preparedness on different topics. Figure 3 shows the mean of all country topic preparedness scores for selected topics, together with the ranges between different countries (Table S1 includes results for all topics and rates of ‘no teaching’). Table 1 shows the topics associated with the highest and lowest preparedness, based on the mean of all country topic preparedness scores, as well as the topics with the greatest variations between countries. Two of the topics with the highest rates of students reporting no teaching were among the three topics for which students reported the lowest preparedness: (i) to communicate with senior doctors in situations where...
antibiotics are not necessary, but they feel they are being inappropriately pressured into prescribing antibiotics by senior doctors; and (ii) to measure/audit antibiotic use in a clinical setting and to interpret the results of such studies. The relative ranking order of curriculum topics by preparedness levels was highly consistent across countries (ICC = 0.81, 95% CI = 0.72–0.89).

Teaching methods and assessment
Students rated the usefulness of teaching methods for learning about prudent antibiotic use (Table 2). Discussions of clinical cases, and small-group teaching ranked in the top three methods in 27/28 and 24/28 countries, respectively. E-learning, and role play or communication skills sessions were considered among the three least useful methods in 26/28 and 20/28 countries, respectively. There was wide variation in the use of different teaching methods between countries, for example microbiology clinical placement (12%–95% use), small group teaching (29%–100% use) and active learning assignments (36%–91% use). Over 90% of students reported they had been asked questions on antibiotic treatment in their exams (country range 86%–100%).

Discussion
We assessed self-reported preparedness on a comprehensive range of topics related to responsible antibiotic use among final-year medical students in 29 European countries. Our study has several important findings. First, there were clearly identifiable

Figure 2. Associations between national antibiotic susceptibility score, need for more education and global preparedness score. Countries were grouped into tertiles based on national antibiotic susceptibility score: low antibiotic susceptibility score, meaning higher resistance prevalence rates for four common pathogens, (n = 10); medium antibiotic susceptibility score (n = 9); and high antibiotic susceptibility score (n = 9). Comparisons were made using analysis of variance; *P < 0.05.

Figure 3. Percentage of European medical students who reported feeling at least sufficiently prepared in selected topics on prudent antibiotic use. The chart includes results aggregated first at medical school level within a country, then at country level and then averaged across all participating countries. Error bars display ranges between countries with highest preparedness and lowest preparedness for each topic. The total number of respondents per question varied between 7257 and 7312.
topics in which students feel well prepared, and others in which they feel unprepared. Second, the patterns of relative preparedness between topics were highly consistent across all European countries. Third, most final-year students felt that they still needed more education on antibiotic use for their future practice as junior doctors. Fourth, there were differences between countries in both self-reported levels of preparedness and the need for more education. Fifth, these differences correlated with levels of antibiotic resistance among common bacterial pathogens. We identified topics in which most students felt prepared for their practice as junior doctors, as well as some topics in which over half of all students felt insufficiently prepared. These results are consistent with an earlier study in seven European medical schools, which found that students were more confident in making an accurate diagnosis of infection (92%) than in either planning durations (60%) or choosing combination therapies (40%), and similarly mirrored the results from a survey among junior doctors working in France and Scotland.

The relative patterns of preparedness among the topics were consistent between countries, even though there is no European framework specifying which topics should be prioritized. We anticipate that these patterns will be generalizable beyond the countries participating in our study, particularly to countries with similar medical education programmes. Topics associated with low preparedness levels may be inherently harder to be prepared for or they could be consistently poorly covered at medical schools. There is evidence for the latter explanation in a recent review of curricula at 37 medical schools in 13 European countries, which found low coverage on topics that students in our study reported low feelings of preparedness on (point-of-care tests, estimating durations of antibiotic therapy, surgical prophylaxis). We are not aware of any studies that have assessed the relative difficulty of learning different topics on prudent antibiotic use.

Table 1. Topics on prudent antibiotic use with highest mean self-reported preparedness, lowest mean self-reported preparedness and greatest variation in self-reported preparedness between countries, among European medical students

<table>
<thead>
<tr>
<th>Highest preparedness</th>
<th>Lowest preparedness</th>
<th>Greatest variation in preparedness between countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean percentage of students who feel at least sufficiently prepared:</td>
<td>Mean percentage of students who feel at least sufficiently prepared:</td>
<td>Minimum–maximum percentage of students who feel at least sufficiently prepared:</td>
</tr>
<tr>
<td>to recognize the clinical signs of infection (95.7%)</td>
<td>to communicate with senior doctors in situations where they feel antibiotics are not necessary, but they feel they are being inappropriately pressurised into prescribing antibiotics by senior doctors (43.9%)</td>
<td>to use point-of-care tests (e.g. urine dipstick, rapid diagnostic tests for streptococcal pharyngitis) (22.9%–97.9%)</td>
</tr>
<tr>
<td>to interpret biochemical markers of inflammation (94.7%)</td>
<td>to decide the shortest possible adequate duration of antibiotic therapy for a specific infection (44.5%)</td>
<td>to decide the urgency of antibiotic administration in different situations (e.g. &lt;1 h for severe sepsis, non-urgent for chronic bone infections) (19.5%–90.8%)</td>
</tr>
<tr>
<td>to practise effective infection control and hygiene (89.1%)</td>
<td>to measure/audit antibiotic use in a clinical setting and to interpret the results of such studies (45.9%)</td>
<td>to prescribe antibiotic therapy according to national/local guidelines (35.3%–96.4%)</td>
</tr>
</tbody>
</table>

Table 2. Use and perceived usefulness of teaching methods for antibiotic use among European medical students

<table>
<thead>
<tr>
<th>Teaching method</th>
<th>Useful or very useful (%)</th>
<th>Neutral (%)</th>
<th>Not useful (%)</th>
<th>Not used (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discussions of clinical cases and vignettes</td>
<td>87.7</td>
<td>8.2</td>
<td>1.6</td>
<td>9.3</td>
</tr>
<tr>
<td>Small group teaching (with &lt;15 people)</td>
<td>83.9</td>
<td>10.3</td>
<td>4.0</td>
<td>18.7</td>
</tr>
<tr>
<td>Infectious diseases clinical placement</td>
<td>80.2</td>
<td>13.6</td>
<td>3.0</td>
<td>23.8</td>
</tr>
<tr>
<td>Peer or near-peer teaching</td>
<td>70.1</td>
<td>20.2</td>
<td>5.4</td>
<td>38.3</td>
</tr>
<tr>
<td>Lectures (with &gt;15 people)</td>
<td>67.1</td>
<td>25.3</td>
<td>6.5</td>
<td>3.6</td>
</tr>
<tr>
<td>Active learning assignments</td>
<td>60.1</td>
<td>26.4</td>
<td>9.3</td>
<td>33.8</td>
</tr>
<tr>
<td>Microbiology clinical placement</td>
<td>58.1</td>
<td>27.2</td>
<td>8.1</td>
<td>37.3</td>
</tr>
<tr>
<td>Role play or communication skills sessions</td>
<td>55.5</td>
<td>27.5</td>
<td>11.2</td>
<td>57.5</td>
</tr>
<tr>
<td>E-learning</td>
<td>48.3</td>
<td>34.5</td>
<td>11.6</td>
<td>48.7</td>
</tr>
</tbody>
</table>

The table includes results aggregated first at medical school level within a country, then at country level and then averaged across all participating countries. The total number of respondents per question varied between 6899 and 7020.
of students from the UK, where local and national guidelines have been used for several years, felt sufficiently prepared on prescribing according to guidelines. Interestingly, UK students felt least prepared on selecting initial empirical therapy without using guidelines. Emphasizing the use of guidelines may come at the expense of students learning how to independently select antibiotics for common infections.

Students in some countries, particularly in Northern Europe, consistently reported higher levels of preparedness. Students in these countries may receive better teaching on antibiotics, a hypothesis supported by the internal correlation with lower expressed needs for further education in the same countries. An alternative explanation is that certain cultural factors are associated with a general feeling of being prepared, which yields higher reported feelings of preparedness on specific topics such as antibiotic use. Too few studies have investigated general preparedness among medical students for us to be able to assess this potential explanation further. At the individual level, a systematic review tentatively linked low preparedness levels for working as a junior doctor with certain factors (high levels of neuroticism and uncertainty avoidance) and high levels of preparedness with others (high levels of agreeableness, conscientiousness and extraversion). Another explanation could be the relationship between prevalence of antibiogram resistance and preparedness levels: students in countries with low levels of antibiotic resistance in common bacterial pathogens may feel more prepared simply because they face fewer complicated clinical situations on a daily basis. Inversely, better preparedness could lead to more appropriate antibiotic prescribing in the long term and lower prevalence of antibiotic resistance.

In most European countries, students reaching the end of their medical school studies still felt that they needed more education on antibiotics for their future practice as junior doctors. Studies among students in China, Malaysia, South Africa and the USA similarly found that most students want more education on antibiotics at medical school. A recent survey found that UK medical school programmes contained a median of 17.8 h of education on antimicrobial stewardship. In reality, students will spend more time exposed to the antibiotic prescribing practices of clinical teams they work alongside during medical school. Students may feel confused and less prepared if the activities of these prescribers (which represent a hidden curriculum) are inconsistent, particularly if they conflict with formal teaching sessions. To our knowledge, this is the largest ever study to assess medical student preparedness on any topic. Through developing an effective network of country coordinators, we received responses from students at over half of all European medical schools. We investigated subjective self-reported preparedness. Although case vignettes may have provided a more objective assessment of preparedness, no validated set of case vignettes exists on responsible antibiotic use and it may even be hard for such vignettes to assess individual curriculum topics. Furthermore, we contend that understanding how students perceive their preparedness remains important in planning teaching. For example, the high levels of reported preparedness on recognizing clinical signs of infection (98% sufficiently prepared) and on differentiating between bacterial and viral upper respiratory tract infections (82% sufficiently prepared) may represent overconfidence; misdiagnosis is indeed a leading cause of unnecessary antibiotic usage. The relative rankings of self-reported preparedness may help identify topics that students feel more attention should be given to. Future studies should consider combining assessments of self-reported preparedness and case vignettes on a more limited range of topics, ideally using the native language of respondents. In addition, studies should consider including a set of control questions on preparedness on topics and behaviours not directly connected to antibiotic prescribing; this would allow comparisons of preparedness to be made across a broader range of clinical disciplines and activities. Low participation is a common challenge of survey studies with students, and our response rates were indeed low at many institutions. We were missing data on the eligible numbers of students from a fifth of medical schools and we have not been able to compare responders and non-responders. These limitations should not detract from the generalizability of our findings, given the lack of strong association between response rate and preparedness, as well as the consistency between countries in topics with low preparedness scores.

In conclusion, many final-year European medical students do not feel sufficiently prepared to prescribe antibiotics responsibly and we have identified areas for improvement. Further research is needed to understand how students’ self-reported preparedness reflects observed preparedness and how this in turn translates into clinical practice. Meanwhile, we hope that our results provide useful insight for those currently teaching medical students how to prescribe antibiotics. A key consideration is which areas of low preparedness should now be prioritized for improvement; such a judgement should consider both feasibility and likely impact on responsible antibiotic use. Within ESCMID and ESGAP we plan to raise awareness by publicizing these results among our members and among policymakers, and we are now developing generic competencies in antimicrobial stewardship for all prescribers.

Acknowledgements
We thank all students who participated in the study and all medical school coordinators for their efforts in conducting the study.

Other members of the ESGAP Student-PREPARE Working Group

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The study was carried out as part of our routine work.

Transparency declarations
None to declare.

Author contributions
O. J. D., D. N., D. L. M., I. C. G., C. S. L. and C. P. contributed to the study design. O. J. D. and C. P. contributed to the implementation and supervision...
of the study. I. C. G., C. S. L. and C. P. and other members of the ESGAP Student-PREPARE Working Group acted as country coordinators during the study. O. J. D. analysed the data and takes responsibility for the accuracy of the data analysis. O. J. D. and C. P. drafted the manuscript. All authors and other members of the ESGAP Student-PREPARE Working Group read and approved the final manuscript.

**Supplementary data**

The survey instrument, Tables S1 and S2, List S1 and Figures S1–S3 are available as Supplementary data at JAC Online.

**References**


