International Journal of Antimicrobial Agents 54 (2019) 375–379

Contents lists available at ScienceDirect

International Journal of Antimicrobial Agents

journal homepage: www.elsevier.com/locate/ijantimicag

Short Communication

Appropriate antibiotic prescribing among final-year medical students in Europe

Tim van der Voort[a,b,*], David J. Brinkman[a,b], Silvia Benemei[c], Ylva Böttiger[d], Bernard Chamontin[e], Thierry Christiaens[f], Robert Likic[g], Romaldas Mačiulaitis[h], Toomas Marandi[i], Emilia C. Monteiro[j], Paraskevi Papaioannidou[k], Yves M. Pers[l], Caridad Pontes[m], Aleksandar Raskovic[n], Ralf Regenthal[o], Emilio J. Sanz[p], Kurt Wilson[q], Jelle Tichelaar[a,b], Michiel A. van Agtmael[a,b], on behalf of the Working Group Research on CPT Education of the European Association for Clinical Pharmacology and Therapeutics (EACPT)

[a] Department of Internal Medicine, Amsterdam University Medical Center, Amsterdam, The Netherlands
[b] Research and Expertise Center in Pharmacotherapy Education (RECIPE), Amsterdam, The Netherlands
[c] Unit of Clinical Pharmacology, Careggi University Hospital, University of Florence, Firenze, Italy
[d] Department of Medical and Health Sciences, Linköping University, Linköping, Sweden
[e] Department of Internal Medicine and Hypertension, University of Toulouse, Toulouse, France
[f] Department of Clinical Pharmacology, Ghent University, Ghent, Belgium
[g] Unit of Clinical Pharmacology, Department of Internal Medicine, University Hospital Centre Zagreb and University of Zagreb School of Medicine, Zagreb, Croatia
[h] Faculty of Medicine, Lithuanian University of Health Sciences, Kaunas, Lithuania
[i] Department of Cardiology, University of Tartu, Tartu, Estonia
[j] NOVA Medical School, Universidade NOVA de Lisboa, Lisbon, Portugal
[k] Department of Pharmacology, School of Medicine, Faculty of Health Sciences, Aristotle University of Thessaloniki, Thessaloniki, Greece
[l] Clinical Immunology and Osteoarticular Diseases Unit, Department of Rheumatology, CHU Montpellier, University of Montpellier, Montpellier, France
[m] Department of Pharmacology, Autonomous University of Barcelona, Barcelona, Spain
[n] Department of Pharmacology, Toxicology and Clinical Pharmacology, University of Novi Sad, Novi Sad, Serbia
[o] Department of Clinical Pharmacology, Leipzig University, Leipzig, Germany
[p] School of Medicine, Universidad de La Laguna, Tenerife, Spain
[q] Faculty of Medicine, University of Manchester, Manchester, UK

ARTICLE INFO

Article history:
Received 29 August 2018
Accepted 1 May 2019

Editor: R.A. Seaton

Keywords:
Antibiotics
Pneumonia
Education

ABSTRACT

Little is known about undergraduate education on antibiotic prescribing in Europe and even less about the antibiotic prescribing skills of nearly-graduated medical students. This study aimed to evaluate the antibiotic prescribing skills of final-year medical students across Europe and the education they received during medical training. In a cross-sectional study, final-year medical students from 17 medical schools in 15 European countries were asked to prescribe for two written case reports of infectious diseases (acute bronchitis and community-acquired pneumonia). The appropriateness of antimicrobial therapy was determined using a scoring form based on local guidelines. Teachers from each medical school were asked to complete a standardised questionnaire about the teaching and assessment of undergraduate education on antibiotic use. In total, 856 final-year medical students (95.6%) completed the assessment and 16 teachers (94.1%) completed the questionnaire. Overall, 52.7% (range 26–83%) of the 1.683 therapies prescribed were considered appropriate. The mean number of contact hours for undergraduate education on antimicrobials was 25.6 (range 2–90). Differences in education styles were found to have a significant impact on students' performance, with a problem-based learning style being associated with more appropriate antimicrobial prescribing than a traditional learning style (46.0% vs. 22.9%; $P < 0.01$). Although there are differences between medical schools, final-year medical students in Europe lack prescribing skills for two

* Corresponding author. Present address: Pharmacotherapy Section, Department of Internal Medicine, Amsterdam University Medical Center, De Boelelaan 1117, 1081 HV, Amsterdam, The Netherlands. Tel.: +31 20 444 8090.
E-mail address: t.vandervoort1@vumc.nl (T. van der Voort).

https://doi.org/10.1016/j.ijantimicag.2019.05.008

common infectious diseases, possibly because of inadequate undergraduate education on antibiotic use and general prescribing. To improve students' skills, interactive teaching methods such as prescribing for simulated and real patients should be used.

1. Introduction

Appropriate antibiotic prescribing improves patient outcomes in terms of mortality and reduces the development of antimicrobial resistance and healthcare costs [1,2]. The World Health Organization (WHO) identified effective training in antibiotic prescribing during the undergraduate medical curriculum as an important strategy to promote the appropriate use of antimicrobials [3]. Several studies, mainly single-centre, have reported a lack of prescribing confidence and knowledge among medical students and a desire for further education [4–8]. Indeed, most final-year medical students in Europe report a lack of preparedness to prescribe antibiotics [9]. However, none of these studies investigated the antibiotic prescribing skills (i.e. the ability to choose the most appropriate antimicrobial therapy) of European medical students. Therefore, the aim of this multicentre study was to evaluate the antibiotic prescribing skills of final-year medical students across Europe as well as the education they received during medical training.

2. Methods

2.1. Study design

This was a cross-sectional study among final-year medical students and education co-ordinators from 17 medical schools in 15 European countries (Belgium, Germany, Estonia, Spain, France, Greece, Croatia, Italy, Lithuania, the Netherlands, Portugal, Romania, Serbia, Sweden and the UK). The study was part of a larger multicentre project of the European Association for Clinical Pharmacology and Therapeutics (EACPT) between March 2015 and March 2016 [10]. The study was approved by the Dutch Educational Ethics Review Board (NVMO-ERB).

2.2. Materials

A Web-based assessment consisting of two written patient cases of common infectious diseases [acute bronchitis and community-acquired pneumonia (CAP)] was developed and validated by ten European clinical pharmacologists (Supplementary Fig. S1) [10]. Both cases were written in English and were presented in the same format (i.e. general patient data, medical history, medication, allergies, present illness, physical examination, test results, diagnosis). For each case, the student could choose to prescribe a new drug (maximum of two per case), not to prescribe a drug and/or to stop co-medication. If the student decided to prescribe a new drug, s/he had to complete an electronic prescription form, including drug name, dose, dosage, duration of treatment and route of administration.

Undergraduate teaching and assessment of appropriate antibiotic prescribing (e.g. curriculum style, teaching methods, number of contact hours, assessment methods), and students' preparedness for antibiotic prescribing as a junior doctor were evaluated using an 11-item Web-based questionnaire that was developed based on the literature [11,12] as well as our previous work (Supplementary Fig. S2) [10,13]. Definitions were provided where appropriate.

2.3. Participant selection

The participating European schools were part of the EACPT Network of Teachers in Pharmacotherapy (NOTIP) [10,13]. The teacher responsible for undergraduate education on clinical pharmacology and therapeutics at each medical school selected a random sample of approximately 50 final-year medical students. Selected students were informed about the study objective, received instructions and were asked to complete an online assessment (±30 minutes; using surveymonkey.com) under the supervision of the responsible teacher. They were not allowed to consult others during the assessment but were allowed to use the national formulary. Teachers were asked to complete the Web-based questionnaire. Participation was voluntary, without compensation, and was anonymous.

2.4. Scoring

The main researcher (TvdV) assessed the appropriateness of therapy. In cases of doubt, a second author was consulted (DJB). Appropriate antimicrobial therapy was defined as the prescription of an antimicrobial agent that was consistent with the recommendations of the local guideline (provided by the teachers) or that deviated from the local guideline but was a rational choice as judged by the assessor [14]. A rational choice was defined as an effective antimicrobial regimen that covered relevant pathogens without being excessive (i.e. unnecessary combination therapy or broad spectrum when a more narrow spectrum is available) [15]. If the antimicrobial choice, dose interval, dosage, administration route or duration [16] was deemed inappropriate, the therapy was considered inappropriate. The potential for harm of inappropriate therapies was scored (i.e. not immediately harmful, potentially harmful, potentially lethal) (Table 1).

2.5. Statistical analysis

Descriptive variables were expressed as percentages with associated ranges. A weighting factor was used to ensure that each medical school had the same influence in the descriptive analyses. The χ^2 test was used to detect statistically significant relationships between categorical variables. Data were collected and analysed using IBM SPSS Statistics v.23.0 (IBM Corp., Armonk, NY).

3. Results

Between March 2015 and March 2016, 856 medical students from 17 European medical schools completed the online assessment [95.6% response rate; mean number of students per school 50.4 (range 19–218); median age 24 years (range 21–43 years); 58.1% female; and 97.6% European national). Sixteen teachers (94.1%) completed the online survey (31.3% female; mean years of teaching experience 19.3).

3.1. Appropriateness

Overall, 31.2% (range 3–67%) of the therapies for CAP and 75.0% (range 44–100%) of the therapies for acute bronchitis were appropriate (Table 1). The most common type of inappropriate

Table 1
Antibiotic prescribing skills among 856 European final-year medical students from 17 European medical schools for two infectious diseases

	Community-acquired pneumonia	Bronchitis
Total no. of therapies[a]	856	827
Total no. of antibiotic prescriptions	807	207
Therapies conforming to local guidelines (%) (range)	13.4 (0–60)	–
Appropriate overall (%) (range)	31.2 (3–67)	75.0 (44–100)
No. of prescribing errors	672	281
Inappropriate, per category [*n* (%)][b]		
Incorrect indication	–	106 (37.7)
Incorrect drug choice	86 (12.8)	52 (18.5)
Incorrect dosage	132 (19.6)	47 (16.7)
Incorrect duration[c]	75 (11.2)	11 (3.9)
Incorrect dose interval	142 (21.1)	23 (8.2)
Incorrect administration route	50 (7.4)	4 (1.4)
Incomplete/incorrect drug prescription	187 (27.8)	38 (13.5)
Inappropriate, per severity (%) (range)		
Not immediately harmful	34.4 (8–80)	98.1 (0–100)
Potentially harmful	65.2 (20–91)	1.9 (0–10)
Potentially lethal	0.4 (0–1)	–

[a] Therapy = total of newly prescribed drugs or no drug, and/or stopped co-medication.
[b] Cases were scored per category. A single therapy could be scored as incorrect for multiple errors.
[c] A treatment duration of 5–14 days was generally deemed reasonable.

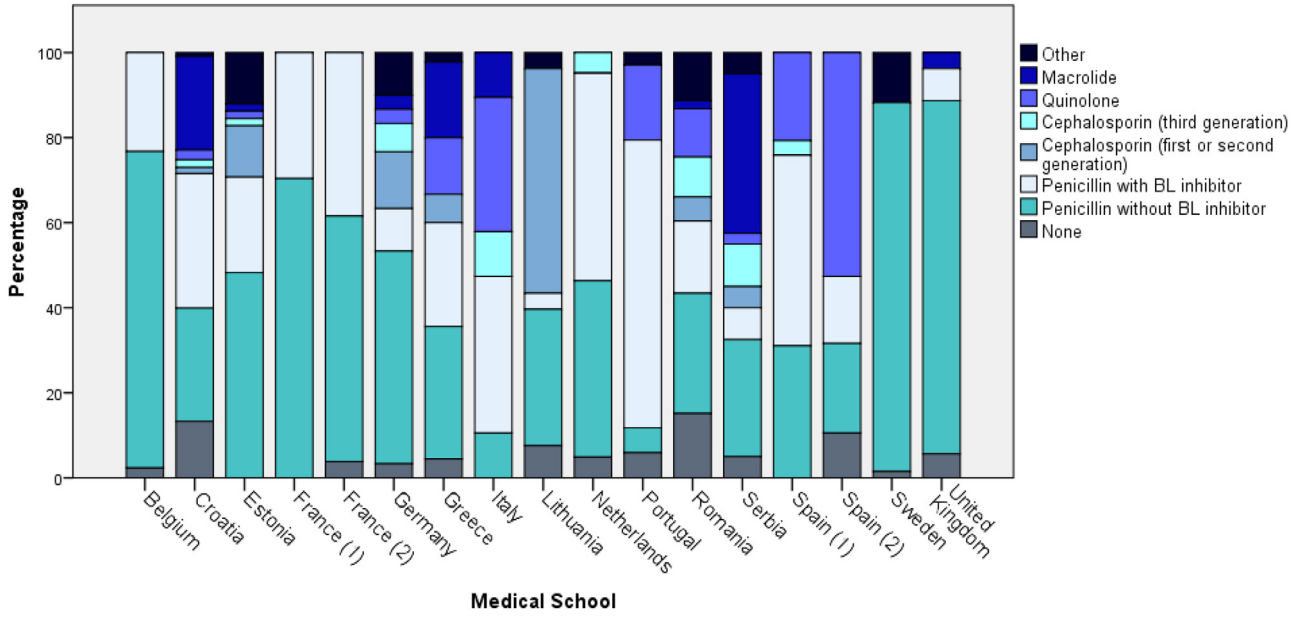

Fig. 1. Groups of antimicrobial agents prescribed for community-acquired pneumonia by final-year medical students in Europe ($n = 856$). Results show primary antibiotic choice as a percentage of all antibiotic prescriptions; 9.5% prescribed double therapy. France and Spain both had two participating medical schools. BL, β-lactamase.

therapy for CAP was 'incomplete/incorrect drug prescription' (27.8%) and 'incorrect dose interval' (21.1%); for bronchitis it was 'incorrect drug choice' (18.5%) and 'incorrect dosage' (16.7%). Most of the inappropriate therapies for CAP were considered 'potentially harmful' (65.2%) and for bronchitis 'not immediately harmful' (98.1%). Students from medical schools in South and East Europe prescribed a greater variety of antimicrobial agents (mean 8.2; range 4–12) for CAP than students from schools in North and West Europe (mean 4.0; range 2–9) (Fig. 1).

3.2. Teaching and assessment

The mean number of training hours for education on antibiotic use was 25.6 (range 2–90). Antibiotic education was typically given in the fourth year (56.3%). Most medical schools (37.4%) used a mix of traditional learning (e.g. lectures, self-directed learning, written exams) and problem-based learning (e.g. small working groups, seminars, patient simulation) methods, 31.3% used mainly traditional learning and 31.3% used mainly problem-based learning methods. In total, 31.1% of medical schools described their final-year medical students as being 'poorly prepared' and 68.7% as 'well prepared' for antibiotic prescribing as a junior doctor.

3.3. Associations

Prescribing appropriateness was significantly higher in medical schools that used problem-based learning methods (mean score 46.0%) than in medical schools that used mixed education (mean score 38.1%) and traditional learning methods (mean score 22.9%) ($P < 0.01$). It was also significantly higher in medical schools which felt that their students were well prepared (44.1%) than in schools which felt their students were poorly prepared for antibiotic prescribing (22.1%) ($P < 0.01$). Students who had received more than 10 training hours in antibiotic prescribing had significantly higher levels of appropriateness compared with students who had received less than 10 training hours (73% vs. 35%; $P < 0.001$).

4. Discussion

Although there are differences between medical schools, these results show that final-year medical students in Europe lack prescribing skills for two common infectious diseases, namely acute bronchitis and CAP. Overall, nearly one-half (47%) of the antimicrobial therapies prescribed were inappropriate, of which 49% were potentially harmful for the patient. This lack of skill among final-year students suggests that undergraduate education on antibiotic use and general prescribing in many European medical schools remains inadequate, although most teachers (69%) thought that their graduates were well prepared. Importantly, poor antibiotic prescribing among nearly-graduated doctors might contribute to antimicrobial resistance, which has become a serious and growing threat to public health [1].

These results are in line with those of previous studies. Recently, Dyar et al. showed that most final-year medical students in Europe lacked self-reported preparedness in antibiotic prescribing and desired further education [9], and Pulcini et al. observed a wide variation in the exposure of students in different European countries to important principles of appropriate antibiotic prescribing [11]. The results of the current study corroborate the notion that undergraduate education on antibiotic use in Europe needs to be improved. Perhaps not surprising, students taught mainly with problem-based learning methods had significantly better prescribing skills than students taught mainly with traditional learning methods, although their skills were still not satisfactory. This result supports the concept that more interactive educational methods, such as small group discussions, patient simulation and clinical prescribing, might improve the antibiotic prescribing skills of future doctors, as suggested previously [9,12]. Moreover, longer training (more training hours) on antibiotic use improved students' performance.

Interestingly, the fact that many of the found prescribing errors are related to incomplete/incorrect drug prescription and incorrect dose interval suggests that participating students lack generic prescribing skills (e.g. how to use a national formulary), which has been shown in our previous study [10]. These generic prescribing skills require more attention during education.

The finding that students from medical schools in South and East Europe prescribed a greater variety of antimicrobial agents than students from schools in North and West Europe might be due to a lack of availability and specificity of antibiotic prescribing guidelines in these regions. For example, Italy, Croatia and Serbia did not have a national guideline on prescribing antibiotics for CAP and bronchitis. Moreover, 41.1% of the provided guidelines lacked sufficient detail, such as antimicrobial choice, dosage and duration. Medical schools should incorporate clear and easily accessible guidelines in their education and should train students how to use guidelines in everyday clinical practice.

This study had some limitations. First, the assessment was in English, which may have influenced students' performance. Second, the sample of students per school was relatively small and cannot be extrapolated to the entire cohort of final-year students in one school or country. Third, students' prescribing skills were only tested for two infectious diseases. Fourth, there may have been selection bias, with participating students being more motivated to participate, or participating medical schools being more ready to devote additional hours to antibiotic education than non-participating medical schools. However, in both cases prescribing performance would probably have been overestimated.

5. Conclusions

This is the first study to show that final-year medical students in Europe lack prescribing skills for two common infectious diseases, which is probably due to inadequate education on antibiotic use and general prescribing during undergraduate education. To change this scenario, we suggest that (i) more interactive educational methods, such as antibiotic prescribing for written, simulated and real patients, should be used; (ii) students should be given more training and education in antibiotic prescribing and general prescribing during undergraduate medical training; and (iii) antibiotic and general prescribing education should be continued during postgraduate training.

Acknowledgments

The authors thank all of the medical students who participated in this study. They are additionally grateful to Prof. De Ponti (University of Bologna, Bologna, Italy), Prof. Corti (University of Florence, Firenze, Italy) and Prof. Kalda (University of Tartu, Tartu, Estonia) for their contribution to the data collection process.

Funding

Funding was provided by the European Association of Clinical Pharmacology and Therapeutics (EACPT).

Competing interests

None declared.

Ethical approval

This study was approved by the Dutch Educational Ethics Review Board (NVMO-ERB).

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ijantimicag.2019.05.008.

References

[1] Bell BG, Schellevis F, Stobberingh E, Goossens H, Pringle M. A systematic review and meta-analysis of the effects of antibiotic consumption on antibiotic resistance. BMC Infect Dis 2014;14:13.
[2] Schuts EC, Hulscher ME, Mouton JW, Verduin CM, Stuart JWTC, Overdiek HWPM, et al. Current evidence on hospital antimicrobial stewardship objectives: a systematic review and meta-analysis. Lancet Infect Dis 2016;16:847–56.
[3] World Health Organization (WHO). The evolving threat of antimicrobial resistance: options for action. France: WHO; 2012. http://www.who.int/iris/handle/10665/44812 [Accessed 29 May 2019].
[4] Wright EP, Jain P. Survey of antibiotic knowledge amongst final year medical students. J Antimicrob Chemother 2004;53:550–1.
[5] Minen MT, Duquaine D, Marx MA, Weiss D. A survey of knowledge, attitudes, and beliefs of medical students concerning antimicrobial use and resistance. Microb Drug Resist 2010;16:285–9.
[6] Ibia E, Sheridan M, Schwartz R. Knowledge of the principles of judicious antibiotic use for upper respiratory infections: a survey of senior medical students. South Med J 2005;98:889–95.
[7] Humphreys H, Dillane T, O'Connell B, Luke LC. Survey of recent medical graduates' knowledge and understanding of the treatment and prevention of infection. Ir Med J 2006;99:58–9.
[8] Abbo LM, Cosgrove SE, Pottinger PS, Pereyra M, Sinkowitz-Cochran R, Srinivasan A, et al. Medical students' perceptions and knowledge about antimicrobial stewardship: how are we educating our future prescribers? Clin Infect Dis 2013;57:631–8.
[9] Dyar OJ, Nathwani D, Monnet DL, Gyssens IC, Stålsby Lundborg C, Pulcini CESGAP Student-PREPARE Working Group. Do medical students feel prepared to prescribe antibiotics responsibly? Results from a cross-sectional survey in 29 European countries. J Antimicrob Chemother 2018;73:2236–42.
[10] Brinkman DJ, Tichelaar J, Schutte T, Benemei S, Böttiger Y, Chamontin BWorking Group Research on CPT Education of the European Association for Clinical Pharmacology and Therapeutics (EACPT). Essential competencies in prescribing: a first European cross-sectional study among 895 final-year medical students. Clin Pharmacol Ther 2017;101:281–9.

[11] Pulcini C, Wencker F, Frimodt-Moller N, Kern WV, Nathwani D, Rodríguez-Baño JESGAP Curriculum Working Group. European survey on principles of prudent antibiotic prescribing teaching in undergraduate students. Clin Microbiol Infect 2015;21:354–61.
[12] Dyar OJ, Pulcini C, Howard P, Nathwani DESGAP (ESCMID Study Group for Antibiotic Policies). European medical students: a first multicentre study of knowledge, attitudes and perceptions of antibiotic prescribing and antibiotic resistance. J Antimicrob Chemother 2014;69:842–6.
[13] Brinkman DJ, Tichelaar J, Okorie M, Bissell L, Christiaens T, Likic REducation Working Group of the European Association for Clinical Pharmacology and Therapeutics (EACPT). Pharmacology and therapeutics education in the European Union needs harmonization and modernization: a cross-sectional survey among 185 medical schools in 27 countries. Clin Pharmacol Ther 2017;102:815–22.
[14] Sikkens JJ, van Agtmael MA, Peters EJG, Lettinga KD, van der Kuip M, Vandenbroucke-Grauls CMJE, et al. Behavioral approach to appropriate antimicrobial prescribing in hospitals: the Dutch Unique Method for Antimicrobial Stewardship (DUMAS) Participatory Intervention Study. JAMA Intern Med 2017;177:1130–8.
[15] Sikkens JJ, Gerritse SL, Peters EJG, Kramer MHH, van Agtmael MA. The 'morning dip' in antimicrobial appropriateness: circumstances determining appropriateness of antimicrobial prescribing. J Antimicrob Chemother 2018;73:1714–20.
[16] van der Meer JW, Gyssens IC. Quality of antimicrobial drug prescription in hospital. Clin Microbiol Infect 2001;7(Suppl 6):12–15.