Journal Pre-proof

Italian Young Doctors' knowledge, attitude and practices on antibiotic use and resistance: A national cross-sectional survey

F. Di Gennaro, C. Marotta, M. Amicone, D.F. Bavaro, F. Bernaudo, E.M. Frisicale, P.K. Kurotschka, A. Mazzari, N. Veronese, R. Murri, M. Fantoni

PII: S2213-7165(20)30230-7

DOI: https://doi.org/10.1016/j.jgar.2020.08.022

Reference: JGAR 1352

To appear in: *Journal of Global Antimicrobial Resistance*

Received Date: 9 June 2020

Revised Date: 23 August 2020

Accepted Date: 31 August 2020

Please cite this article as: Di Gennaro F, Marotta C, Amicone M, Bavaro DF, Bernaudo F, Frisicale EM, Kurotschka PK, Mazzari A, Veronese N, Murri R, Fantoni M, Italian Young Doctors' knowledge, attitude and practices on antibiotic use and resistance: A national cross-sectional survey, *Journal of Global Antimicrobial Resistance* (2020), doi: https://doi.org/10.1016/j.jgar.2020.08.022

Italian Young Doctors' knowledge, attitude and practices on antibiotic use and resistance: a national cross-sectional survey.

Authors: Di Gennaro F [1-2], Marotta C[1-2], Amicone M[1-3], Bavaro D F[1-4], Bernaudo F[1-5], Frisicale E M[1-6,7], Kurotschka P K[1-8], Mazzari A[9], Veronese N[10], Murri R[11], Fantoni M[11]

[1]Italian Young Medical Doctors Association

[2]Department of Epidemiology and Prevention, IRCCS Istituto Neurologico Mediterraneo Neuromed, 86077 Pozzilli, Italy

[3]Department of Public Health, Nefrology Unit, University of Naples Federico II, Naples Italy

[4]Department of Biomedical Sciences and Human Oncology, University of Bari "Aldo Moro", Clinic of Infectious Diseases, Piazza G. Cesare, 11 - 70124, Bari, Italy

[5]Local Health Authority (ASP) Catanzaro, Italy

[6]Local Health Authority (ASL) Roma 1, Rome, Italy

[7]Department of Woman and Child Health and Public Health - Public Health Area, Fondazione Policlinico Universitario A. Gemelli IRCCS, Roma, Italia

[8]Department of medical science and public health, University of Cagliari, Cagliari, Italy

[9]Division of General Surgery, Cristo Re Hospital, Rome, Italy

[10]University of Palermo, Geriatrics Department, Palermo, Italy

[11]Department di Clinica delle Malattie Infettive, Università Cattolica S Cuore, Fondazione Policlinico A Gemelli IRCCS, Roma, Italy

Corresponding author: Bavaro Davide Fiore, MD**,** Department of Biomedical Sciences and Human Oncology, University of Bari "Aldo Moro", Clinic of Infectious Diseases, Piazza G. Cesare, 11 - 70124, Bari, Italy
Mail: davidebavaro@gmail.com
Tel: +39 080 559 2892

Highlights

- A significant lack of knowledge regarding AMR is still present
- AMR was not adequately addressed during participants' medical courses
- Education emerged as an essential keystone of an effective response to AMR
- Stronger investments in training on AMR issues should be urgently implemented

ABSTRACT

Objectives: Antimicrobial resistance (AMR) is one of the major health issues world-wide. Clinicians should play a central role to fight AMR, and medical training is a pivotal issue to contrast it; therefore, assessing levels of knowledge, attitudes and practices among young doctors is essential for future antimicrobial stewardship (AMS) programs.

Methods: A national-wide cross-sectional, multicentre survey was conducted. A descriptive analysis of knowledge and attitudes was performed, along with a univariate and multivariate analysis of their determinants.

Results: Overall, 1179 young doctors accessed the survey and 1055 completed all sections (89.5%). As for the knowledge section of the questionnaire, almost all the participants declared to know the different species of bacteria proposed, however, the percentage of participants who correctly responded to clinical quizzes was of 23% for the question on vancomycin-resistant enterococci (VRE), 42% the one about carbapenem-resistant Enterobacteriaceae (CRE), 32% on extended-spectrum-beta-lactamases (ESBL) producing bacteria and of 27% (285) on methicillin-resistant Staphilococcus aureus (MRSA). Similarly, 81% of participants disagreed in stating that, during their medical training, AMR was adequately addressed and 70% disagreed that they received the right example from their tutors. Finally, a high rate of agreement with the proposed actions to contrast AMR was documented; in particular, percentages of agreement were 75% of respondents who agreed to be part of an active surveillance system or AMS programs.

Conclusions: Tackling AMR should be a priority for politicians and for all health workers. The inclusion of competencies in antibiotic use in all specialty curricula is urgently needed.

Kewords: survey; antimicrobial resistance; antimicrobial stewardship; multidrug resistance; knowledge; attitudes; practice.

INTRODUCTION

Antimicrobial resistance (AMR) is one of the ten threats identified by the World Health Organization (WHO) in 2019, since it affects modern healthcare and the effective prevention and treatment of an ever-increasing range of infections (1). Recent estimates of the burden of AMR are very impressive, with more than half million of infection cases with selected antibiotic-resistant bacteria (2-3) or new emerging resistant pathogens (4-6) occurring in Europe; of note, data regarding AMR in low income countries are largely unknown, increasing the overall risk of mortality, in particular of surgical procedures (7).

Unfortunately, 2019 marked Italy as the top in the European Union (EU) for antibiotic-resistance deaths with over 10,000 of the 33,000 deaths each year caused by bacteria resistant to antibiotics (2). The percentage of resistance to the main classes of antibiotics remains higher in Italy than the European average, albeit within a downward trend compared to the previous years. Furthermore, in 2019, the attributable mortality caused by infections with antibiotic-resistant bacteria was 6.44 deaths per 100,000 population and the overall disability-adjusted-life-years rate was 170 per 100,000 population. Notably, this burden is highest in Italy and Greece than in other European countries (8-9).

Aware of the situation, Italian health authorities are implementing the National-Action-Plan on Antimicrobial Resistance 2017-2020 but this may not be enough. Antibiotic prescribers should play a central role to fight AMR, and medical training on AMR is a pivotal issue to contrast improper use of antibiotics and to develop a culture of AMR.

Knowing the level of knowledge, attitudes and practices of young doctors and how much universities and post-graduate schools perceive AMR as an important educational issue is crucial in the fight against AMR.

For these reasons, we conducted the first Italian survey KAP (knowledge, attitude and practices) involving young doctors from 21 regions and 39 Universities, in order to have a snapshot of the situation on education on AMR and to eventually implement initiatives and culture on AMR.

MATERIAL AND METHODS

Study design and setting

Between February 18, 2020 and March 17, 2020, a cross-sectional, multicentre survey was conducted by administering a validated and anonymous online questionnaire to Italian young medical doctors.

Participants

Italian young medical doctors (MD) younger than 35 years old, including graduated MDs, medical residents and specialists (specialty diploma obtained from <3y) in all medical fields, general practitioner (GP) trainees and GPs (diploma obtained from <3y), practising in all Italian Regions were eligible and invited to participate.

Questionnaire development

A knowledge, attitude and practices (KAP) survey was implemented with an additional focus on AMR education.

The self-administered questionnaire was structured in 19 questions with multiple answers and 5-point Likert-style scale, divided into five sections: 1) Demographics and occupation-related information; 2) Knowledge (related to antimicrobial use and antimicrobial resistance, including clinical quizzes on appropriate management of specific infections for each of the following bacteria: Vancomycin-resistant Enterococcus (VRE), Carbapenem-resistant Enterobacteriaceae (CRE), Extended-spectrum beta-lactamase (ESBL) producing bacteria, Methicillin-resistant Staphylococcus aureus (MRSA); prevalence of different class of antibiotic in Italy; 3) Practices associated with participants' antimicrobial prescribing and administration; 4) Attitudes about possible interventions to optimize

antimicrobial prescribing in Italy and perceptions about the relevance of AMR issue; 5) Education, related to satisfaction about competences acquired during the pre- and post- graduate university offer. The development of the questionnaire was informed by a literature review and content validity was also tested through a panel experts' consultation. Also, the questionnaire was previously pilot tested among 20 young doctors.

The questionnaire was developed on SurveyMonkey (SurveyMonkey Inc., San Mateo, CA, USA) and distributed via mailing list and social media (Facebook, Whatsapp, website) of the Italian Young MDs Association (Associazione Italiana Giovani Medici - SIGM) network.

Statistical analysis

A descriptive analysis was performed to define the distribution of demographic and occupation-related characteristics of the sample and to assess rates of positive/negative attitudes towards and knowledge of AMR (frequencies, percentages, mean values and SD were calculated). The 50 different typologies of post-graduate medical schools providing the residency programs were classified in clinical, non-clinical and surgical area as for Italian Ministry of University and Research classification (DM 68/2015) (**Supplementary File 1**).

An analysis of determinants of knowledge on and attitudes towards contrasting AMR, was conducted through the construction of multiple logistic regression models.

The variables "knowledge on AMR" and "attitudes toward contrasting AMR" originally consisting of multiple categories, were collapsed into two levels: **a *high level of knowledge on AMR*** was attributed to respondents providing correct responses to at least three of five quizzes included in section knowledge of the questionnaire; **a *positive attitudes towards contrasting AMR*** were defined as positive attitudes towards the two of the three statements included in section attitudes of questionnaire.

Covariates included in the models were: type of education background (primary care vs hospital), participants' gender, age, exposure to training on AMR during undergraduate, main area of work (surgical, clinical, non-clinical).

Multiple logistic regression models were built. Each variable was examined by univariate analysis using the appropriate statistical test (Student's t-test or $\chi 2$ test) and was included in the model when the p-value was less than 0.25. Subsequently, multivariate logistic regression with backward elimination of any variable that did not contribute to the model on the grounds of the Likelihood Ratio test (cut- off, $p = 0.05$) was performed. Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. All statistical calculations were performed using Stata version 15.0 (Stata Corporation, College Station, TX, USA).

RESULTS

Participants

One-thousand-one-hundred-seventy-nine young doctors accessed the survey and 1055 completed all sections (89.5%). Mean age was of 29.1 ± 3.4 years and 659 (62%) were women. Among all young doctors participating the survey, 610 (69%) had a hospital background being medical residents (41%, 437) or already specialized (16%,173), 272 (31%) were from primary care setting being GP trainees (13%,142) or GPs (12%, 130), while 73 (16%) were MDs graduated from medical school with no further educational path. As for specialists and medical residents, 270 (44%) were from clinical fields, 186 (30%) from non-clinical and 154 (25%) from surgical sectors **(Table 1).** All Italian Universities hosting medical residencies (39) and all Italian Regions (21) hosting regional specific GP courses were represented (data not shown).

Among all participants, 925 (88%) declared to be an antibiotic prescriber and of them 618 (67%) to prescribe antibiotic several times per day.

Knowledge

As for the knowledge section of the questionnaire, almost all the participants declared to know the different species of bacteria proposed (**Table 2**). In particular, 933 (94%) participants declared to know what VREs are, 949 (90%) to know CREs, 980 (93%) ESBLs and 1045 (99%) MRSAs. These percentages decreased when reporting to have personal experience with patients infected with these bacteria: 640 (61%) participants declared to have managed patients with VRE, 712 (67%) patients with CRE, 730 (69%) patient with ESBL and 802 (76%) patients with MRSA. On the other hand, participants who correctly responded to clinical quizzes were 247 (23%) for the question on VRE, 439 (42%) the one about CRE, 336 (32%) on ESBL and of 285 (27%) on MRSA **(Table 2)**. Finally, when asking to correctly order the current prevalence ESBLs, MRSA, CRE and VRE in Italy, 457 (43%) participants identified the correct sequence **(Table 2)**.

Practices

Practices on antibiotic prescribing of young doctors are reported in **Table 3.**

Attitudes and perception

A high rate of agreement with the proposed actions to contrast AMR was documented and reported in **Table 4.** In particular, 797 (75%) respondents agreed (or strongly agreed) to be part of an active surveillance system through a specific monitoring network on AMR, 892 (85%) agreed (or strongly agreed) to be collaborative in setting up an Antimicrobial Stewardship Program in their hospital/health district, 942 (89%) agreed (or strongly agreed) to introducing a multidisciplinary teaching on AMR into the medical curriculum (**Table 4**).

Most of participants agreed (or strongly agreed) in rating the current level of AMR as an important problem for global health (997, 95%), for Italy (955, 91%), but this percentage decreased when referring to their hospital and district (859, 82%), or their ward, clinic and local health unit (810, 77%) (**Table 4**).

Education

One-hundred and two participants agreed (or strongly agreed) that education on AMR was adequately addressed, during the pre-graduation medical course (40, 4%) and during the residency program or GP course (62,10%), respectively (**Table 4**).

Also, 744 (70%) participants disagreed (or strongly disagreed) with the statement *"During my training course, I received the right example from my tutors on the correct use of antibiotics and AMR".* On the contrary, even if 982 (93%) respondents agreed (or strongly agreed) in considering important the training on AMR, 830 (79%) of them disagreed (or strongly disagreed) in considering themselves adequately trained on this area of medical knowledge.

This was in line with 729 (69%) young doctors participating the survey reporting not to have received any training offer on AMR by their curricular training both under and post-graduated, only 166 (16%) to have received lessons from internal professors, or external experts (69, 7%) and 91 (9%) meetings with pharmaceutical companies (**Figure 1**).

Table 5 summarizes the results of the multivariate analysis. A *high level of knowledge on antibiotic use and resistance* was associated with having the perception of the importance of AMR issue, having received training on AMR during undergraduate education and with the awareness of having knowledge on AMR. Finally, *positive attitudes* towards actions and initiative to contrast AMR were associated with being an antibiotic prescriber, having the perception of AMR's importance, having received training on AMR during undergraduate education, having had a good mentors' example, and with the awareness of AMR training importance.

DISCUSSION

To the best of our knowledge, this is one of largest surveys exploring the knowledge, attitudes and practices of young doctors with respect to antimicrobial use and resistance, and the first one conducted in Italy. Several papers have shown that antibiotic prescribing is not sufficiently covered in the undergraduate medical curricula or during specialty training (10-14) with underestimated daily practice perceptions and skills (15-16). Poor education on AMR especially in junior doctors represents a European issue requiring European advocacy.

Notably, despite all Italian regions are at high risk of resistant bacteria according to recent data published by European Centre for Disease Prevention and Control (2), only two thirds of participants thought that VRE, ESBL, CRE or MRSA were an epidemiologically relevant problem in their district/hospital. This lack of knowledge regarding bacterial resistance epidemiology is consistent with previous surveys conducted in other countries in past years (17-20) although antimicrobial resistance was less diffuse in those countries if compared to Italy when the surveys were conducted.

In addition, the clinical knowledge was also investigated in this survey. Overall, only one third or less of participants correctly answered the questions on VRE, MRSA, ESBL and CRE, although more than 90% of them declared to be familiar with multidrug resistant pathogens, and more than two third declared to have managed patients with infections caused by those bacteria.

However, data deriving from education section should be read to complete the picture. Indeed, most respondents acknowledged that AMR was not adequately addressed during their pre- and post-graduation training courses. These findings should be considered both at national and local level, especially in order to draft appropriate antimicrobial stewardship programs but also to draft future pre- and post-graduation courses. In fact, education, communication and training may probably be the keystone of an effective response to antimicrobial resistance in future years (21), as it has been demonstrating also for other issues such as vaccination among healthcare workers (22). Surprisingly, courses dedicated to prudent and correct use of antibiotics, infection control measures and antimicrobial resistance are still lacking in current medical education curricula, although all medical specialists usually prescribe antibiotics in clinical practice, as showed also by answers of this survey. Moreover, two third of participants reported that their tutors were not able to provide a valid example in terms of antimicrobial stewardship during their clinical practice. This underscores the need to evaluate and possibly improve the daily clinical practice as a pivotal tool in fighting AMR. Accordingly, a recent review on this topic (23) supported the critical value of step-by-step processes in antimicrobial stewardship programs, with frequent revisions and real-time feedbacks, in order to quickly fix problems and mistakes. Physicians should not be left alone with their concerns, and the inaccuracies should be promptly resolved.

Notably, this study did not find significant differences in responses by comparing diverse specializations, Italian regions or by comparing Hospital specialists with primary care physicians; albeit the primary care setting presents different barriers to appropriate AMR programs if compared with hospital setting (24). Therefore, a coordinated and tailored approach should be implemented in

all these different situations to achieve optimal results. Barriers to the implementation of AMR programmes should be recognized and addressed accordingly (25).

Almost all participants were aware that antimicrobial resistance is one of the major issues in terms of global and Italian health and were fully available to be involved in active surveillance and antimicrobial stewardship programs. Unsurprisingly, being young, antimicrobial prescriber and trained on this field resulted to be predictor of a positive attitudes in taking actions to contrast AMR, while having awareness of the issue and being properly trained on antibiotics usage and resistance were independent predictors of an higher level of knowledge of AMR.

Consequently, these data support further investments in training on AMR issues and their rapid implementation, because training young people means planning the future. To this purpose a curricula guide for healthcare workers' education and training on AMR is already available by WHO in 2019 (26). Our findings suggest different workable actions: i) the introduction of an AMR course within the medical degree program and during the residency programs ii) the setting up an Antimicrobial Stewardship Program in health district and hospital, iii) the institution a network on AMR, with the AMR sentinel doctors directly involved in monitoring and evaluating trend in AMR in their health districts and hospitals.

These actions supported by the Italian junior doctors' sample in study could help in reducing the burden of resistance and therefore of deaths and in increasing culture and knowledge on AMR.

Strengths of this work are the large sample size, the wide participation from all Italian regions and medical specialities, including general practitioners, and the investigation of knowledge, attitudes and practices of young Italian doctors.

This study has some limitations. First, as with most surveys, there is a possibility that respondents gave socially desirable answers. To minimize this potential bias, we ensured complete respondent confidentiality. Second, although the sample size is quite large, it could be not representative of all settings. Finally, questions about personal experience are subject to recall bias.

In conclusion, AMR represents a serious health problem, compromising the treatment of infectious diseases and undermining many other advances in health and medicine. Tackling AMR should be a priority for politicians and for all health workers. The inclusion of competencies in antibiotic use in all specialty curricula is urgently needed, as suggested by results of this study.

DECLARATIONS

Funding: No

Competing Interests: No

Ethical Approval: Not required. Participation was voluntary, anonymous and without compensation. Informed consent for completion of the questionnaire was declared on the first page.

CONTRIBUTION

FDG, CM, MR, FM were involved in the conception and design of the work; FDG, CM, DFB produced the first draft of the manuscript; all authors revised the paper critically for intellectual content and gave the final approval of the version to be published and agree to be accountable for all aspects of the work.

REFERENCES

[1] World Health Organization. Ten Threats to Global Health in 2019. WHO, 2019. Available online: https://www.who.int/emergencies/ten-threats-to-global-health-in-2019 (accessed on 1 May 2019).

[2] European Centre for Disease Prevention and Control. Surveillance of antimicrobial resistance in Europe 2018. Stockholm: ECDC; 2019.

[3] Adler A, Katz DE, Marchaim D. The continuing plague of extended-spectrum beta-lactamase-producing Enterobacteriaceae infections. Infect Dis Clin N Am. 2016;30(2):347–75.

[4] Brooke JS. Stenotrophomonas maltophilia: an emerging global opportunistic pathogen. Clin Microbiol Rev. 2012;25(1):2-4.

[5] Liao CH, Chang HT, Lai CC, et al. Clinical characteristics and outcomes of patients with Burkholderia cepacia bacteremia in an intensive care unit. Diagn Microbiol Infect Dis. 2011;70(2):260-266.

[6] Bavaro DF, Mariani MF, Stea ED, Gesualdo L, Angarano G, Carbonara S. Sphingomonas paucimobilis outbreak in a dialysis room: Case report and literature review of an emerging healthcare associated infection [published online ahead of print, 2020 Mar 5]. Am J Infect Control. 2020;S0196-6553(20)30069-9. doi:10.1016/j.ajic.2020.01.018.

[7] Di Gennaro F, Marotta C, Pisani L, et al. Maternal caesarean section infection (MACSI) in Sierra Leone: a case-control study. Epidemiol Infect. 2020;148:e40. Published 2020 Feb 27. doi: 10.1017/S0950268820000370.

[8] Cassini A, Högberg LD, Plachouras D, et al. Attributable deaths and disability-adjusted life-years caused by infections with antibiotic-resistant bacteria in the EU and the European Economic Area in 2015: A population-level modelling analysis. Lancet Infect. Dis. 2019, 19, 56–66.

[9] Tacconelli E, Pezzani MD. Public health burden of antimicrobial resistance in Europe. Lancet Infect. Dis. 2019, 19, 4–6.

[10] Rawson TM, Butters TP, al. Exploring the coverage of antibiotic stewardship across UK clinical postgraduate training curricula. J Antimicrob Chemother 2016; 71: 3284–92.

[11] Levin C, Thilly N, Dousak M et al. Perceptions, attitudes, and practices of French junior physicians regarding antibiotic use and resistance. Med Mal Infect 2019; 49: 241–9.

[12] Sánchez-Fabra D, Dyar OJ, Del Pozo JL, et al. Perspective of Spanish medical students regarding undergraduate education in infectious diseases, bacterial resistance and antibiotic use. Enferm Infecc Microbiol Clin. 2019;37(1):25-30.

[13] Mazzucco W, Marotta C, de Waure C, et al. Motivational aspects and level of satisfaction of italian junior doctors with regard to knowledge and skills acquired attending specific general practice training courses. A national web survey. Euromediterranean Biomedical Journal 2017,12 (17) 077–08. Doi: 10.3269/1970-5492.2017.12.17.

[14] Mazzucco W, Lanza G, Gaglio V, et al. Medical workforce planning in a changing health context: comparison between Italy and Europe. Euromediterranean Biomedical Journal 2019, 2019,14 (11) 049–055 .doi: 10.3269/1970-5492.2019.14.11.

[15] Naqvi A, Pulcini C. Bacterial resistance and antibiotic prescription: a survey of hospital physician perception, attitude, and knowledge. Med Mal Infect. 2010;40(11):625-631.

[16] Spernovasilis N, Ierodiakonou D, Milioni A, et al. Assessing the knowledge, attitudes and perceptions of junior doctors on antimicrobial use and antimicrobial resistance in Greece. J Glob Antimicrob Resist 2019 Nov 11;21:296-302. doi: 10.1016/j.jgar.2019.11.0043.

[17] Wester CW, Durairaj L., Evans AT, et al. Antibiotic resistance: a survey of physician perceptions. Arch Intern Med, 162 (2002), pp. 2210-2216.

[18] Pulcini C, Williams F, Molinari N, et al. Junior doctors' knowledge and perceptions of antibiotic resistance and prescribing: a survey in France and Scotland. Clin Microbiol Infect. 2011 Jan;17(1):80-7.

[19] Pulcini C,Wencker F, Frimodt-Møller N et al. European survey on principles of prudent antibiotic prescribing teaching in undergraduate students. Clin Microbiol Infect 2015; 21: 354–61.

[20] Beović B, Doušak M, Pulcini C, et al. Young doctors' perspectives on antibiotic use and resistance: a multinational and inter-specialty cross-sectional European Society of Clinical Microbiology and Infectious Diseases (ESCMID) survey. J Antimicrob Chemother. 2019;74(12):3611–3618. doi:10.1093/jac/dkz375.

[21] Lee CR, Lee JH, Kang LW, Jeong BC, Lee SH. Educational effectiveness, target, and content for prudent antibiotic use. Biomed Res Int. 2015;2015:214021. doi:10.1155/2015/214021

[22] Costantino C, Restivo V, Gaglio V, et al. Effectiveness of an educational intervention on seasonal influenza vaccination campaign adherence among healthcare workers of the Palermo University Hospital, Italy. Ann Ig. 2019 Jan 1;31(1):35-44. doi: 10.7416/ai.2019.2256.

[23] Mendelson M, Morris AM, Thursky K, et al. How to start an antimicrobial stewardship programme in a hospital. Clin Microbiol Infect. 2020 Apr;26(4):447-453.

[24] Jeffs L, McIsaac W, Zahradnik M, et al. Barriers and facilitators to the uptake of an antimicrobial stewardship program in primary care: A qualitative study. PLoS One. 2020;15(3):e0223822. Published 2020 Mar 5. doi:10.1371/journal.pone.0223822.

[25] Fantoni M, Murri R, Cauda R. Antibiotic stewardship from toolkit to local implementation: the 'gutta cavat lapidem' strategy. Future Microbiol. 2017;12:935-938.

[26] World Health Organization. Health workers' education and training on antimicrobial resistance: curricula guide. Geneva: World Health Organization; 2019. Licence: CC BY-NC-SA 3.0 IGO. https://apps.who.int/iris/bitstream/handle/10665/329380/9789241516358-eng.pdf (accessed on 16 July 2020).

Table 1. Demographics and occupation-related information of 1055 junior doctors participating the survey.

Characteristics		**N (%)**
Sex *(n. of respondents= 1055)*	Female	659 (62%)
	Male	396 (38%)
Occupational profile *(n. of respondents = 1055)*	GP trainees	142 (13%)
	Specialized MD (< 3 years)	173 (16%)
	GP (< 3 years)	130 (12%)
	Medical doctors	173 (16%)
	Residents Medical doctors	437 (41%)
Educational and working background *(n. of respondents = 882)*	Primary care	272 (31%)
	Hospital	610 (69%)
Area of medical work *(n. of respondents = 610)*	Surgical	154 (25%)
	Clinic	270 (44%)
	Non-clinic	186 (30%)

Legend: GP= general practitioner; MD= medical doctors

Table 2. Knowledge on AMR of 1055 junior doctors participating the survey.

		Yes	No	I Don't Know
		N (%)	N (%)	N (%)
VRE	Do you know what *vancomycin-resistant Enterococcus* (VRE) are?	993 (94%)	62 (6%)	-
	Have you ever managed a patient with VRE?	640 (61%)	415 (39%)	-
	Do you think patients in your hospital/ health district are at risk of VRE?	674 (64%)	76 (7%)	305 (29%)
	Do you think that VREs are an epidemiologically relevant problem in your hospital/district?	572 (54%)	129 (12%)	354 (34%)
	Do you think that a patient with previous VRE infection should be placed in contact isolation?	610 (58%)	**247 (23%)**	198 (19%)
CRE	Are you familiar with *carbapenem-resistant Enterobacteriaceae* (CRE)?	949 (90%)	106 (10%)	-
	Have you ever managed CRE patients?	712 (67%)	343 (33%)	-
	Do your hospital patients have an increased risk of CRE infections?	648 (61%)	74 (7%)	333 (32%)
	Do you think that CRE is an epidemiologically relevant problem in your hospital/health district?	645 (61%)	90 (9%)	320 (30%)
	In presence of carbapenemase, does the MIC of meropenem rarely exceed 8 µg / ml (particularly, in the case of *Klebsiella* KPCs producing)?	219 (21%)	**439 (42%)**	397 (38%)
ESBL	Do you know what *beta-lactamase-producing enterobacteria* (ESBL) are?	980 (93%)	75 (7%)	-
	Have you ever managed patients with ESBL infection?	730 (69%)	325 (31%)	-
	Do you think patients in your hospital/GP clinic are at risk of infections caused by ESBL?	467 (44%)	316 (30%)	272 (26%)
	Do you think your hospital/health district has an epidemiologically relevant problem with ESBL infections?	376 (36%)	365 (35%)	314 (30%)
	Is an ESBL-producing *E. coli* normally resistant to piperacillin and ceftriaxone, but sensitive to piperacillin/tazobactam?	**336 (32%)**	504 (48%)	215 (20%)
MRSA	Do you know what a methicillin resistant *Staphylococcus aureus* is?	1045 (99%)	10 (1%)	-
	Have you ever managed patients with MRSA infection?	802 (76%)	253 (24%)	-
	Do you think patients in your hospital/district are at risk of developing MRS*A* infections?	569 (54%)	313 (30%)	173 (16%)
	Do you think your hospital/district has an epidemiologically relevant problem with MRSA?	426 (40%)	390 (37%)	239 (23%)
	Should a patient who has a *Staphylococcus aureus* infection with MIC for oxacillin of 4 µg/ml be considered infected with a methicillin-resistant strain?	**285 (27%)**	473 (45%)	297 (28%)

Which is the correct order of prevalence in Italy	N (%)
1. ESBLs > MRSA > VRE > CRE	149 (14%)
2. MRSA > ESBLs > CRE > VRE	339 (32%)
3. ESBLs > MRSA > CRE > VRE	**457 (43%)**
I don't know	110 (10%)

Legend: MIC= minimal inhibitory concentration; **boldface** means correct answer.

Table 3. Antibiotics prescribing practices of 1055 junior doctors participating the survey.

Thinking about the last week, how often have the following events occurred?	Never	Once a week	Three times a week	Once a day	Many times a day
	n (%)	n (%)	n (%)	n (%)	n (%)
Before prescribing an antibiotic, I always conduct a thorough physical examination	66 (6%)	61 (6%)	69 (7%)	181 (17%)	678 (64%)
I prescribe antibiotics when the patient expects and/or expressly asks for it (especially the parents of the children)	718 (68%)	74 (7%)	39 (4%)	82 (8%)	142 (13%)
When prescribing antibiotics, I take time to provide understandable information for the patient about their correct use	85 (8%)	83 (8%)	87 (8%)	195 (18%)	605 (57%)
I prescribe an antibiotic because "it is less expensive in terms of time and energy" than explaining to the patient why it is not indicated	746 (71%)	62 (6%)	58 (5%)	95 (9%)	94 (9%)
I prescribe an antibiotic when the patient has the flu to prevent over infections/subsequent bacterial infections	680 (64%)	151 (14%)	87 (8%)	79 (7%)	58 (5%)
I prescribe antibiotic because the patient has independently started the antibiotic treatment	606 (57%)	189 (18%)	85 (8%)	101 (10%)	74 (7%)
Before prescribing an antibiotic, I consult national and international guidelines	115 (11%)	252 (24%)	139 (13%)	393 (37%)	156 (15%)
I prescribed antibiotics in order to maintain a good relationship with the patient	743 (70%)	139 (13%)	95 (9%)	50 (5%)	28 (3%)
I stopped the antibiotic treatment before the foreseen duration by the national and international guidelines	720 (68%)	154 (15%)	76 (7%)	64 (6%)	41 (4%)
I prescribed antibiotic because I could not follow-up the patient	710 (67%)	178 (17%)	60(6%)	64 (6%)	43 (4%)
I prescribed antibiotic for fear of the patient's reporting	798 (76%)	127 (12%)	48 (5%)	57 (5%)	25 (2%)
I prescribed antibiotic for fear that I am not recognizing a bacterial infection/fear to be considered incompetent	744 (71%)	200 (19%)	58 (5%)	41(4%)	12 (1%)

Table 4. Attitudes, perceptions and education on AMR of 1055 junior doctors participating the survey.

	Statement	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
		n (%)	n (%)	n (%)	n (%)	n (%)
attitudes	I am available to be part of an active surveillance system through a specific monitoring network on AMR	6 (1%)	36 (3%)	216 (20%)	511 (48%)	286 (27%)
	I would be collaborative in setting up an Antimicrobial Stewardship Program in my hospital/health district	4 (0%)	15 (1%)	144 (14%)	578 (55%)	314 (30%)
	I'm favorable in introducing a multidisciplinary teaching on AMR into the medical curriculum	2 (0%)	10 (1%)	101 (10%)	531 (50%)	411 (39%)
perception	The current level of antibiotic resistance is an important problem for global health	0 (0%)	1 (0%)	57 (5%)	331 (31%)	666 (64%)
	The current level of antibiotic resistance is an important problem for Italy	0 (0%)	2 (0%)	98 (9%)	616 (59%)	339 (32%)
	The current level of antibiotic resistance is an important problem for my Hospital or my health district	0 (0%)	15 (1%)	181 (17%)	606 (57%)	253 (24%)
	The current level of antibiotic resistance is an important problem for my ward, clinic, local health unit	3 (0%)	29 (3%)	213 (20%)	577 (55%)	233 (22%)
education	During the pre-graduation course, the theme of AMR was adequately addressed	317 (30%)	594 (56%)	104 (10%)	34 (3%)	6 (1%)
	During the specialization course / GP course AMR was adequately addressed	190 (18%)	663 (63%)	140 (13%)	42 (4%)	20 (2%)
	During my training course, I received the right example from my tutors on the correct use of antibiotics and AMR	106 (10%)	638 (60%)	216 (20%)	70(7%)	25 (2%)

	Training on AMR issues is important	4 (0%)	18 (2%)	51 (5%)	345(33%)	637 (60%)
	I feel adequately trained about AMR	149 (14%)	681 (65%)	174 (16%)	40 (4%)	11 (1%)

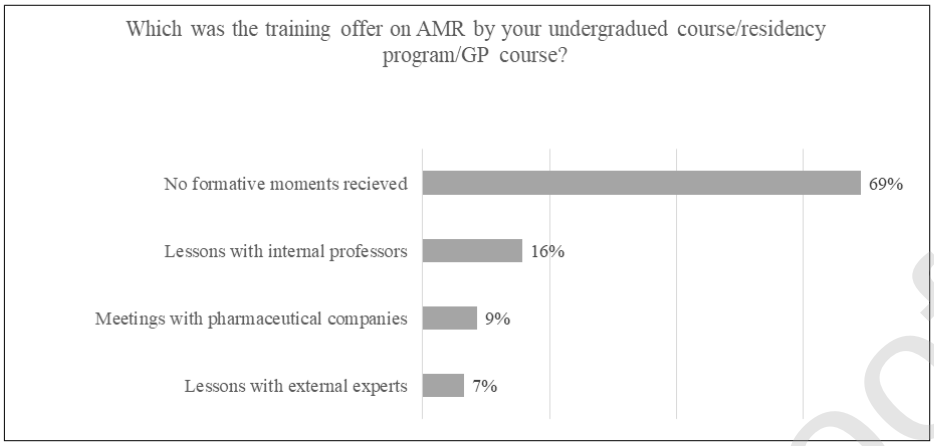
Table 5. Multivariate analysis of determinants of knowledge and attitudes.

	OR	95% CI	P value
Higher level of knowledge of AMR			
Sex			
male female	reference 1,183	0.833 - 1,680	0,348
Age	0,969	0,914 – 1,027	0,287
Occupational profile			
GP or GP trainees specialists or residents Graduated	reference 1,408 0,733	 0,932 -2,128 0,397 – 1,356	 0,104 0,322
Antibiotic prescribers			
no yes	reference 1,163	0,671 – 2,014	0,591
Perception of importance of AMR			
no yes	reference 1,480	1,914 – 2,733	**0,001**
Exposure during med school			
no yes	reference 1,448	1,050 – 2,802	**0,007**
Exposure during post graduated training			
no yes	reference 1,136	0,675-1,911	0,632
Good mentors' example			
no yes	reference 1,445	0,927 – 2,253	0,104
Importance of training on AMR			
no yes	reference 0,842	0,258 – 2,747	0,776
Awareness of knowledge on AMR			
no yes	reference 2,663	1,652 – 4,291	**0,000**
Positive attitude towards actions vs AMR			
no yes	reference 1,429	0,860 – 2,375	0,168
Positive attitudes towards actions to contrast AMR			
Sex			
male female	reference 1,223	0,854 – 1,753	0,271
Age	**0,919**	**0,874-0,966**	**0,001**
Occupational profile			

GP or GP trainees specialists or residents Graduated	reference 0,762 1,041	 0,485 - 1,196 0,548 – 1,979	 0,237 0,903
Antibiotic prescribers			
no yes	reference 1,754	1,093 - 2,815	**0,020**
Perception of importance of AMR			
no yes	reference 2,537	1,658 -3,881	**0,000**
Exposure during med school			
no yes	reference 1,467	1,289 – 2,757	**0,002**
Exposure during post graduated training			
no yes	reference 1,102	0,660 – 1,839	0,711
Good mentors' example			
no yes	reference 1,564	1,365 – 2,872	**0,010**
Importance of training on AMR			
no yes	reference 3,108	1,208 – 7,997	**0,019**
Awareness of knowledge on AMR			
no yes	reference 0,910	0,551- 1,503	0,714
Knowledge towards actions vs AMR			
low high	reference 1,456	0,875 – 2,424	0,148

Legend: GP= general practitioners; AMR= antimicrobial resistance; **boldface** means statistically significant.

Figure.1 Curricular training offer on AMR reported by 1055 junior doctors participating the survey



Legend: GP= general practitioners; AMR= antimicrobial resistance; **boldface** means statistically significant.