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Italian young doctors' knowledge, attitudes and practices on antibiotic use and resistance: A national cross-sectional survey

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ABSTRACT

Objectives: Antimicrobial resistance (AMR) is one of the major health issues worldwide. Clinicians should play a central role to fight AMR, and medical training is a pivotal issue to combat it; therefore, assessing levels of knowledge, attitudes and practices among young doctors is essential for future antimicrobial stewardship (AMS) programmes.
Methods: A nationwide, cross-sectional, multicentre survey was conducted in Italy. 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 (89.5%) completed all sections. Regarding the knowledge section of the questionnaire, almost all participants declared to know the different species of bacteria proposed, however the percentage of participants who correctly responded to clinical quizzes was 23% for the question on vancomycin-resistant enterococci (VRE), 42% on carbapenem-resistant Enterobacteriaceae (CRE), 32% on extended-spectrum β-lactamase-producing enterobacteria (ESBL) and 27% on methicillin-resistant*Staphylococcus aureus* (MRSA). Similarly, 81% of participants disagreed in stating that AMR was adequately addressed during their medical training and 71% disagreed that they received the right example from their tutors. Finally, a high rate of agreement with the proposed actions to combat AMR was documented; in particular, the percentage agreement was 76% for respondents who agreed to be part of an active surveillance system or AMS programme.
Conclusions: Tackling AMR should be a priority for politicians and for all health workers. Inclusion of competencies in antibiotic use in all specialty curricula is urgently needed.

1. 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 significant, with more than half a million cases of infection 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 in surgical procedures [7].

Unfortunately, 2019 marked Italy as the European Union country with the highest antibiotic resistance-related deaths,

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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 with 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 higher 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 in the fight against AMR, and medical training on AMR is a pivotal issue to combat improper use of antibiotics and to develop a culture of antimicrobial stewardship (AMS).

Knowing the level of knowledge, attitudes and practices of young doctors and to what extent universities and postgraduate schools perceive AMR as an important educational issue is crucial in the fight against AMR.

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

2. Materials and methods

2.1. Study design and setting

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

2.2. Participants

Italian young medical doctors aged <35 years, including graduated medical doctors, medical residents and specialists (specialty diploma obtained from <3 years) in all medical fields, as well as general practitioner (GP) trainees and GPs (diploma obtained from <3 years), practising in all Italian regions were eligible and invited to participate.

2.3. Questionnaire development

A KAP survey was implemented with an additional focus on AMR education.

The self-administered questionnaire was structured in 19 questions with multiple answers and a 5-point Likert-style scale, divided into five sections: (i) demographics and occupation-related information; (ii) knowledge related to antimicrobial use and AMR, including clinical quizzes on appropriate management of specific infections [vancomycin-resistant enterococci (VRE), carbapenem-resistant Enterobacteriaceae (CRE), extended-spectrum β-lactamase-producing enterobacteria (ESBL) and methicillin-resistant *Staphylococcus aureus* (MRSA)] and the prevalence of different antibiotic resistances in Italy; (iii) practices associated with participants' antimicrobial prescribing and administration; (iv) attitudes about possible interventions to optimise antimicrobial prescribing in Italy and perceptions about the relevance of the AMR issue; and (v) education, related to satisfaction about competences acquired during pregraduate and postgraduate university education.

Development of the questionnaire was informed by a literature review and content validity was also tested through an expert panel consultation. The questionnaire was also previously pilot tested among 20 young doctors.

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

2.4. 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 standard deviation were calculated). The 50 different typologies of postgraduate medical schools providing residency programmes were classified into clinical, non-clinical and surgical areas as for the Italian Ministry of University and Research classification (DM 68/2015) (Supplementary File 1).

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

The variables 'knowledge on AMR' and 'attitudes toward combating 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 questions included in the knowledge section of the questionnaire; and a positive attitude towards combating AMR was defined as a positive attitude toward two of the three statements included in the attitudes section of the questionnaire.

Covariates included in the models were: type of educational background (primary care versus hospital); participants' sex; participants' age; exposure to training on AMR during undergraduate training; and 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 χ^2 test) and was included in the model when the P-value was <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 and 95% confidence intervals were calculated. All statistical calculations were performed using Stata v.15.0 (Stata Corp., College Station, TX, USA).

3. Results

3.1. Participants

A total of 1179 young doctors accessed the survey and 1055 (89.5%) completed all sections. The mean age of respondents was of 29.1 ± 3.4 years and 659 (62%) were female. Among all young doctors participating in the survey, 610/882 (69%) had a hospital background being medical residents (41%; 437) or already specialised (16%; 173), and 272/882 (31%) were from a primary care setting being GP trainees (13%; 142) or GPs (12%; 130), whilst 173 (16%) were medical doctors graduated from medical school with no further educational path. Regarding specialists and medical residents, 270/610 (44%) were from clinical fields, 186/610 (30%) from non-clinical sectors and 154/610 (25%) from surgical sectors (Table 1). All Italian universities hosting medical residencies ($n = 39$) and all Italian regions ($n = 21$)

Table 1
Demographics and occupation-related information of junior doctors ($n = 1055$) participating the survey.

Characteristic (no. of respondents)	*N* (%)
Sex (1055)	
Female	659 (62)
Male	396 (38)
Occupational profile (1055)	
GP trainee	142 (13)
Specialised MD (<3 years)	173 (16)
GP (<3 years)	130 (12)
MD	173 (16)
Medical resident	437 (41)
Educational and working background (882)	
Primary care	272 (31)
Hospital	610 (69)
Area of medical work (610)	
Surgical	154 (25)
Clinical	270 (44)
Non-clinical	186 (30)

GP, general practitioner; MD, medical doctor.

hosting regional specific GP courses were represented (data not shown).

Among all participants, 925 (88%) declared to be an antibiotic prescriber, of which 618/925 (67%) prescribed antibiotics several times per day.

3.2. Knowledge

Regarding the knowledge section of the questionnaire, almost all of the participants declared to know the different species of bacteria proposed (Table 2). In particular, 993 (94%) participants declared to know what VRE are, 949 (90%) to know CRE, 980 (92.9%) to know ESBLs and 1045 (99%) to know MRSA. 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%) patients with ESBLs 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%) for the question about CRE, 336 (32%) for the question on ESBLs and 285 (27%) on MRSA (Table 2). Finally, when asking to correctly order the current prevalence of ESBLs, MRSA, CRE and VRE in Italy, 457 (43.3%) participants identified the correct sequence (ESBL > MRSA > CRE > VRE) (Table 2).

3.3. Practices

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

3.4. Attitudes and perception

A high rate of agreement with the proposed actions to combat AMR was documented (Table 4). In particular, 797 (76%)

Table 2
Knowledge on antimicrobial resistance (AMR) of junior doctors ($n = 1055$) participating the survey.

		Yes [*N* (%)]	No [*N* (%)]	I don't know [*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 VRE 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 extended-spectrum β-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 MRSA 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)	

MIC, minimum inhibitory concentration; GP, general practitioner.
NOTE: Boldface indicates correct answer.

Table 3
Antibiotic prescribing practices of junior doctors ($n = 1055$) participating the survey.

Thinking about the last week, how often have the following events occurred?	Never [n (%)]	Once a week [n (%)]	Three times a week [n (%)]	Once a day [n (%)]	Many times a day [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 antimicrobial resistance (AMR) of junior doctors ($n = 1055$) participating the survey.

	Statement	Strongly disagree [n (%)]	Disagree [n (%)]	Neither agree nor disagree [n (%)]	Agree [n (%)]	Strongly agree [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 specialisation 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)

GP, general practitioner.

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 AMS programme in their hospital/health district and 942 (89%) agreed (or strongly agreed) to introducing 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%) and for Italy (955; 91%), but this percentage decreased when referring to their hospital and district (859; 81%), or their ward, clinic or local health unit (810; 77%) (Table 4).

3.5. Education

A total of 102 participants agreed (or strongly agreed) that education on AMR was adequately addressed during the pregraduate medical course (40; 4%) and during the residency programme or GP course (62; 6%), respectively (Table 4).

Also, 744 (71%) 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'. In contrast, although 982 (93%) respondents agreed (or strongly agreed) in considering training on AMR important, 830 (79%) of

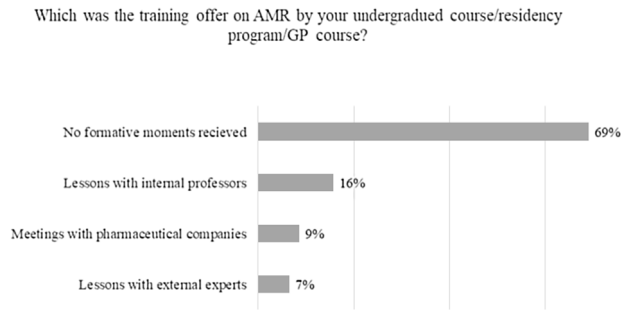

Fig. 1. Curricular training on antimicrobial resistance (AMR) reported by junior doctors ($n = 1055$) participating in the survey. GP, general practitioner.

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 in the survey reporting not to have received any training on AMR by their curricular training both pregraduate and postgraduate, only 166 (16%) to have received lessons from internal professors or external experts (69; 7%), and 91 (9%) meetings with pharmaceutical companies (Fig. 1).

Table 5 summarises 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 the 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 initiatives to combat AMR were associated with being an antibiotic prescriber, having the perception of the importance of AMR, having received training on AMR during undergraduate education, having had a good mentors' example, and with awareness of the importance of training on AMR.

4. 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 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 being at high risk of resistant bacteria according to recent data published by the European Centre for Disease Prevention and Control (ECDC) [2], only two-thirds of participants thought that VRE, ESBLs, 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 AMR was less diffuse in those countries compared with Italy when the surveys were conducted.

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

However, data deriving from the education section should be read to complete the picture. Indeed, most respondents acknowledged that AMR was not adequately addressed during their pregraduate and postgraduate training courses. These findings should be considered both at national and local levels, especially in order to draft appropriate AMS guidelines but also to draft future pregraduate and postgraduate courses. In fact, education, communication and training may be the keystone of an effective

Table 5
Multivariate analysis of determinants of knowledge and attitudes.

	OR	95% CI	*P*-value
Higher level of knowledge of AMR			
Sex			
Male	Ref.		
Female	1.183	0.833–1.680	0.348
Age	0.969	0.914–1.027	0.287
Occupational profile			
GP or GP trainees	Ref.		
Specialists or residents	1.408	0.932–2.128	0.104
Graduated	0.733	0.397–1.356	0.322
Antibiotic prescribers			
No	Ref.		
Yes	1.163	0.671–2.014	0.591
Perception of importance of AMR			
No	Ref.		
Yes	1.480	1.014–2.733	**0.001**
Exposure during medical school			
No	Ref.		
Yes	1.448	1.050–2.802	**0.007**
Exposure during postgraduate training			
No	Ref.		
Yes	1.136	0.675–1.911	0.632
Good mentors' example			
No	Ref.		
Yes	1.445	0.927–2.253	0.104
Importance of training on AMR			
No	Ref.		
Yes	0.842	0.258–2.747	0.776
Awareness of knowledge on AMR			
No	Ref.		
Yes	2.663	1.652–4.291	**0.000**
Positive attitude towards actions against AMR			
No	Ref.		
Yes	1.429	0.860–2.375	0.168
Positive attitudes towards actions to combat AMR			
Sex			
Male	Ref.		
Female	1.223	0.854–1.753	0.271
Age	0.919	0.874–0.966	**0.001**
Occupational profile			
GP or GP trainees	Ref.		
Specialists or residents	0.762	0.485–1.196	0.237
Graduated	1.041	0.548–1.979	0.903
Antibiotic prescribers			
No	Ref.		
Yes	1.754	1.093–2.815	**0.020**
Perception of importance of AMR			
No	Ref.		
Yes	2.537	1.658–3.881	**0.000**
Exposure during medical school			
No	Ref.		
Yes	1.467	1.289–2.757	**0.002**
Exposure during postgraduate training			
No	Ref.		
Yes	1.102	0.660–1.839	0.711
Good mentors' example			
No	Ref.		
Yes	1.564	1.365–2.872	**0.010**
Importance of training on AMR			
No	Ref.		
Yes	3.108	1.208–7.997	**0.019**
Awareness of knowledge on AMR			
No	Ref.		
Yes	0.910	0.551–1.503	0.714
Knowledge towards actions against AMR			
Low	Ref.		
High	1.456	0.875–2.424	0.148

OR, odds ratio; CI, confidence interval; AMR, antimicrobial resistance; GP, general practitioners.
NOTE: Boldface indicates statistical significance.

response to AMR in future years [21], as has been demonstrated 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 AMR are still lacking in current medical education curricula, although all medical specialists usually prescribe antibiotics in clinical practice, as shown also by the answers of this survey.

Moreover, two-thirds of participants reported that their tutors were not able to provide a valid example in terms of AMS 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 AMS programmes, 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 specialisations or Italian regions or by comparing hospital specialists with primary care physicians, albeit the primary care setting presents different barriers to appropriate AMS programmes compared with the hospital setting [24]. Therefore, a co-ordinated and tailored approach should be implemented in these different situations to achieve optimal results. Barriers to the implementation of AMS programmes should be recognised and addressed accordingly [25].

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

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

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

Strengths of this work are the large sample size, wide participation from all Italian regions and medical specialities, including GPs, 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 minimise 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 the results of this study.

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Ethical approval

Not required; participation was voluntary, anonymous and without compensation. Informed consent for completion of the questionnaire was declared on the first page.

Conflict of interests

None declared.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.jgar.2020.08.022.

References

[1] World Health Organization (WHO). Ten threats to global health in 2019. Geneva, Switzerland: WHO; 2019. . (Accessed 1 May 2019) https://www.who.int/news-room/spotlight/ten-threats-to-global-health-in-2019.
[2] European Centre for Disease Prevention and Control (ECDC). Surveillance of antimicrobial resistance in Europe 2018. Stockholm, Sweden: ECDC; 2019.
[3] Adler A, Katz DE, Marchaim D. The continuing plague of extended-spectrum β-lactamase-producing Enterobacteriaceae infections. Infect Dis Clin North Am 2016;30:347–75.
[4] Brooke JS. *Stenotrophomonas maltophilia*: an emerging global opportunistic pathogen. Clin Microbiol Rev 2012;25:2–4.
[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;70:260–6.
[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. Am J Infect Control 2020, doi:http://dx.doi.org/10.1016/j.ajic.2020.01.018 Mar 5 [Epub ahead of print].
[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, doi:http://dx.doi.org/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, Moore LSP, Castro-Sánchez E, Cooke FJ, Holmes AH. 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 [in Spanish]. Enferm Infecc Microbiol Clin 2019;37:25–30.
[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 Biomed J 2017;12:077–86, doi:http://dx.doi.org/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 Biomed J 2019;14:049–55, doi:http://dx.doi.org/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 [in French]. Med Mal Infect 2010;40:625–31.
[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;21:296–302, doi:http://dx.doi.org/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 2002;162:2210–6.
[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;17:80–7.

[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;74:3611–8, doi:http://dx.doi.org/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:http://dx.doi.org/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;31:35–44, doi:http://dx.doi.org/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;26:447–53.
[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:e0223822, doi:http://dx.doi.org/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;12:935–8.
[26] World Health Organization (WHO). Health workers' education and training on antimicrobial resistance: curricula guide. Geneva, Switzerland: WHO; 2019. . [accessed 16 July 2020] https://apps.who.int/iris/bitstream/handle/10665/329380/9789241516358-eng.pdf.