Medical students' views on the current and future antibiotic resistance situation

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ABSTRACT

Objective
This study aims to investigate medical student's perception of the extent and impact of antibiotic resistance (AR). The study will also investigate medical students' perception of their own role as future physicians when having to deal with this issue.

Material and Methods
A survey, containing 24 questions, on medical students' attitudes toward AR was distributed within an international medical student organization. Valid responses were obtained from 501 students from 70 nations representing all five continents.

Results
The main findings of this study are that (i) students from high income countries do not consider AR as big of a problem as students from low and middle income countries do (ii) students view on factors important to reduce AR in their own country reflects the policies on antibiotic sales and purchase in their country (iii) medical students believe that doctors and governments are the two main stakeholders responsible for reducing AR (iv) medical students believe that they can contribute to the work being done to reduce AR (v) and finally, medical students believe that they will be able to rely on available standard treatment guidelines, laboratory reports about the current bacterial resistance patterns, and the knowledge they gain during their medical education as the main sources of information about prudent use of antibiotics and AR.

Conclusion
Medical students have a good understanding of the risk of contributing to AR by prescribing antibiotics irrationally in their future clinical work. They also show a good understanding of their potential of being a part of the solution and a willingness to contribute. However, they do acknowledge the need for more education about this problem, and there is therefore an urgent need to improve education on antibiotic treatment and AR in medical curricula, and that this issue is addressed repeatedly during their medical training.

INTRODUCTION

When antibiotics were first introduced in the 1940s it revolutionized the world of medicine transforming once deadly diseases into manageable infections. The importance of antibiotics to infectious diseases is hard to deny. However antibiotics have also proven to play a significant role enabling the development of life-saving interventions in other medical fields where prevention and treatment of secondary bacterial complications are essential. Many surgical procedures, transplantations and treatments of immune deficient patients such as cancer patients undergoing chemotherapy, preterm babies and people living with HIV/AIDS (PLWHA) all require access to effective antibiotics (1, 2).

Unfortunately the past decades use and misuse of antibiotics have resulted in rapidly increasing levels of antibiotic resistant bacteria, leading to a loss of antibiotic efficacy. The effects of antibiotic resistance (AR) can be seen all over the world in the form of failed medical treatments and prolonged infections. By following the development of AR it became clear that resistance can be spread across borders, from country to country. Due to increased travel and trade between countries there is an increase in resistant strains spreading over the world, making antibiotic resistance a global problem. A recent example of this is the emergence and worldwide spread of carbapenemases among the *Enterobacteriaceae* family of bacteria (3). Carbapenemases are a group of clinically important β-lactamases that efficiently hydrolyse most β-lactam antibiotics, including the carbapenems which are often used as last resort treatment for multidrug resistant infections. For patients infected with Carbapenemase-producing *Enterobacteriaceae* (CPE), there is no rational choice of antibiotic therapy and treatment often relies on old and toxic antibiotics such as colistin (4). In the last decade, there has been a rapid increase in CPE worldwide, with certain areas reporting higher rates, e.g. USA, Israel, Greece, Puerto Rico, Colombia, the southern Mediterranean region and the Indian subcontinent (5).

Research shows that treatment failure due to antibiotic resistance is associated with an increased risk for secondary complication, increased mortality rates and increased economical costs causing great strain on patients and health care systems worldwide (6, 7, 8). It should therefore be a top priority for everybody affected (patients, general population, health care professional and students, politicians and governments etc.) that the problem of AR is addressed and solved.

Organizations such as World Health Organization (WHO), ReAct- Action on Antibiotic Resistance and Centers for Disease Control and Prevention (CDC) are calling for global action to respond to the AR challenge (2, 9, 10). Key components are the urgent need to develop new classes of medicines to replace the old ones losing their effect, but equally important is to develop strategies to safeguard the effect of current and future antibiotics by acting on the underlying reasons to the AR situation. If we do not learn how to preserve the precious resource of antibiotics, AR will become a never ending problem.

The reasons behind the emergence and spread of resistant bacteria are many, but antibiotic use is often pointed out as one of the key drivers of resistance (2, 9, 11). All antibiotic use, both rational and irrational contributes to the selection and spread of resistant bacteria. The fact is that as long as we choose to use antibiotics there will be a risk of AR emerging. Studies have showed a strong correlation between the levels of antibiotic use and AR, where populations with lower levels of antibiotic use also have lower levels of resistant bacteria (12). Restricting irrational and excessive antibiotic use is therefore considered to be a top priority to slow down the development of AR. Large efforts to date have focused on physician education to improve their prescribing habits, with varying results (13). While targeting clinical behaviors is important, it has previously been shown that changing professional habits as they have already been established for a long time-period might be difficult. Exposing medical students to training

on AR as well as motivate and support them in taking action on the problem should therefore be a key component in any comprehensive AR strategy (14).

Medical students all over the world will in a few years enter the global health work force and become one of the most influential stakeholders in the medical field. They will inherit the possibilities of modern medicine but also the problems connected to it, including AR. Interventions targeting medical students is therefore both necessary and pose a great opportunity to strengthen the efforts to decrease AR. By influencing the next generation of physicians, before they have developed the bad habits of prescribing antibiotics for the wrong reasons, overprescribing can be decreased. A study in the UK showed that by educating undergraduates and graduates at education level on antibiotic prescribing and resistance, quality of future antibiotic prescribing can improve (15).

Despite the obvious advantage of targeting future prescribers, very few studies that focus on researching medical student's attitude on AR can be found. Minen et al. conclude that medical students perceive AR as a serious problem; however the majority did not believe that their own hospitals overprescribed antibiotics. The study also showed that even though there were no clear resources of preference to obtain education on antimicrobials, medical students relied heavily on older colleagues and a majority desired greater feedback on their antimicrobial treatment choices (16). These results are concordant with the results of Pulcini et al., where an evaluation of the attitude of junior doctors in France and Scotland showed that 95% of the survey population perceived AR as a national problem, while only 63% rated AR a problem in their own daily practice. When asked what the most helpful interventions for improving prescribing of antibiotics were the junior doctors answered educational sessions, availability of microbiological and infectious diseases specialists advice and guidelines (17). In a study by Humphrey et al. where recent medical graduates were asked to answer a questionnaire on common infections, the results show that the graduates knowledge about antibiotics where poorly answered compared to the other questions (18). Ibia et al. concludes that senior medical students have large gaps in their knowledge of the appropriate use of antimicrobial agents when treating upper respiratory infections (19). Finally, in the study made by Pulcini et al. the participants, in addition to answering questions about their attitude towards AR, had to answer questions about the prevalence of AR which showed great limitations of knowledge (17).

The above mentioned studies suggests that medical students and young doctors, despite having received a medical education, lack knowledge on appropriate use of antibiotics and AR, and feel that they have to rely on information from older colleagues and guidelines. There is a danger that students educate themselves through older colleagues, whose knowledge might not be up to date, and the need for improvement in the education on antibiotics and AR in the medical curriculum is obvious.

It is important to assess the knowledge of medical students to be able to understand how to break bad habits of irresponsible use of antibiotics within global health care. With the aim to obtain better insight to medical students' attitudes towards the challenges of AR, we performed a survey through the International Federation of Medical Student Association (IFMSA), the largest global medical student network. The study aimed to investigate medical students' perception of the current and future AR situation, its underlying reasons and possible solutions, together with how they perceived their role as medical student in addressing the AR problem.

MATERIAL AND METHODS

A draft questionnaire was developed and thereafter reviewed and pre-tested by a small group of representatives from the IFMSA and the international network ReAct-Action on Antibiotic Resistance. The survey was modified according to their comments.

The final questionnaire contained four sections with a total of 24 questions (Appendix 1). The first section contained 10 questions researching background information such as nationality, gender, semester, field of study, age etc. The following section focused on the participants view on the current situation on AR in their own country and consisted of 5 questions. In this section participants were asked to answer questions about the severity of the problems regarding AR in their country, what the main reasons for AR where and whether or not the issue is being addressed in their own country. The third sections addressed the students' views on the future situation and possible solutions. The section contained 4 questions and asked the participant to estimate how often they would be affected by AR in their future professional life as a physician and what they considered being the 3 most important factors to reduce AR in their own country. The final section focused on ways of reaching out to students. The 4 questions in this section focused on the participants view on students' possibilities to contribute to the work on preserving antibiotics and what the best ways would be to reach out to this specific population.

The questionnaire was distributed to members of the IFMSA (20) one of the largest organizations organizing medical students globally. It is an independent, non-governmental and non-political federation of medical students' associations currently representing national medical student associations in 97 countries on six continents, with around 1,200,000 members worldwide.

Distribution of the survey took place at two different occasions. First a total of 321 printed copies of the survey were distributed randomly to participants at the General Assembly of the IFMSA. The meeting took place in Copenhagen, Denmark, on the 1st to 6th of August, hosting a total number of 1050 participants. This was followed by the distribution of a link to an online version of the survey on September the 1st on the server of the IFMSA and on the 6th of October on the server of the IFMSA-Sweden (21), a member organization of the IFMSA. The reason for sending out the survey on more than one server was to be able to reach more students within the IFMSA. The difference in dates was caused by difficulties in accessing the servers' distributional systems. One reminder to fill in the online version of the survey was sent out on the two servers. The survey was closed on the 21st of November. The online version of the survey was made using the program Google docs (22).

By feeding in data from the hard copies of the survey into the online version all data was gathered in the same program. The data was then downloaded to a Microsoft Excel (Microsoft Corporation) spreadsheet and descriptive statistics was generated by stratification according to geographical and socioeconomic variables on national levels. Countries were respondents studied were classified to reflect geographical distribution by using WHOs regional division (23) and socioeconomic region by applying World Bank (24). The data was then summarized according to regional differences, year of study and gender. The study had two inclusion criteria, all participants had to be medical student (graduated and pre-medical students were excluded) and secondly all participants had to be a member of the International Federation of Medical Student Association, IFMSA.

Statistical differences were tested by determining 95% confidence intervals by the normal approximation method for binomial proportions by using the on-line statistical calculator available at http://www.mccallum-layton.co.uk/stats/

According to the educational guidelines of the Sahlgrenska Academy, University of Gothenburg, no ethical assessment or approval has to be applied for when writing a thesis during the medical education. Therefore this has not been done.

RESULTS

Characteristics of participants

A total of 519 students answered the questionnaire, out of which 172 respondents (33 %) answered the paper version at the IFMSA general assembly and 347 respondents (67 %) answered the online version at googledocs.com. 18 questionnaires (11 of the paper versions and 7 of the online version) where excluded from the study because they did not satisfy the inclusion criteria or because they did not finish the questionnaire (Figure 1).

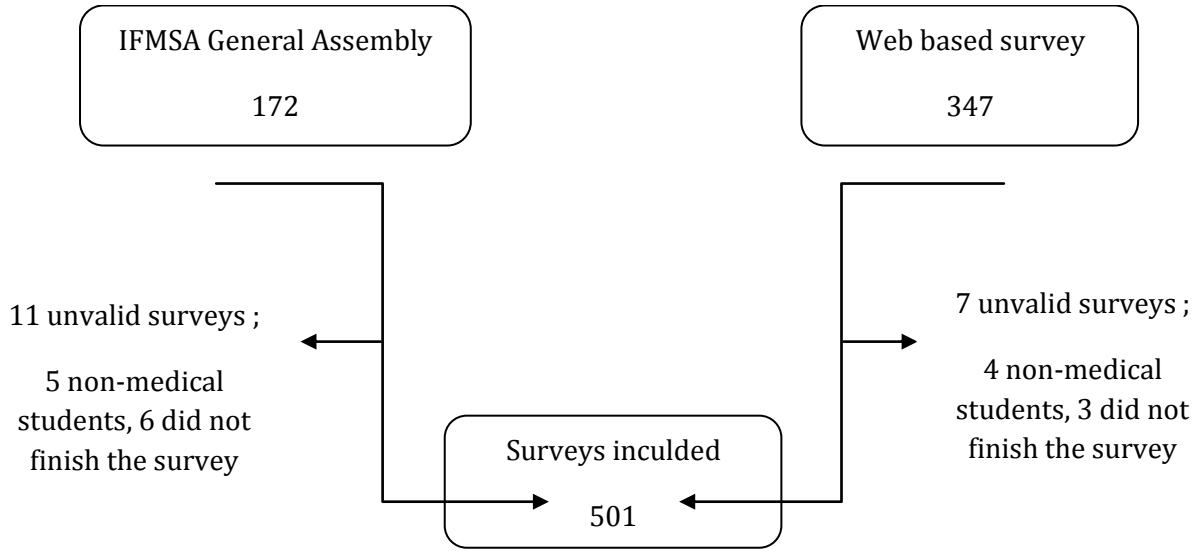

Figure 1. Overview of data collection process.

Out of all the participants 235 (47%) had attended the General Assembly; African Region (AFR) 8%, Region of the Americas (AMR) 25%, Eastern Mediterranean Region (EMR) 15%, European Region (EUR) 41%, South East Asian Region (SEAR) 1%, West Pacific Region (WPR) 11%. The gender distribution, both total and amongst participants who attended the GA, were approximately 56 % female and 44% male. 74 (15%) of the survey population had attended a session or workshop about antibiotic resistance at the GA in Denmark.

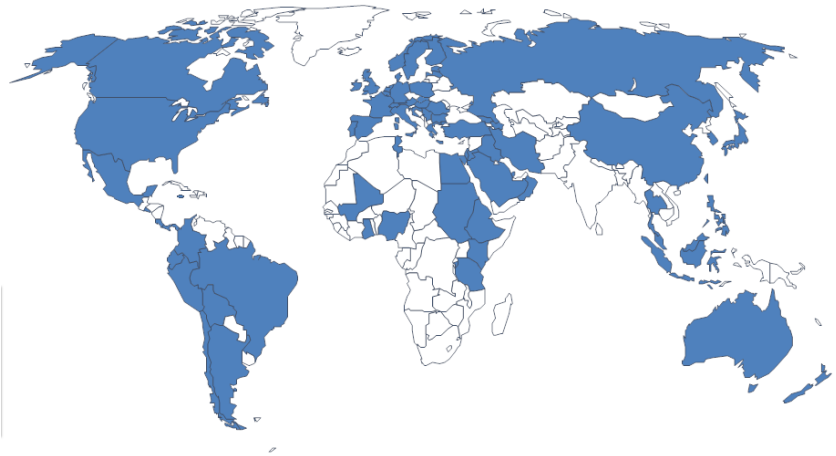

Figure 2. Respondents geographical location for medical studies: blue color indicates countries represented by the respondents.

As seen in Figure 2, responses from 70 nations representing all five continents were registered. The majority of the respondents were from high income countries (HIC) (n: 324, 65%), followed by upper middle income countries (UMIC) (n: 132, 27%), lower middle income countries (LMIC) (n: 29, 6%) and low income countries (LIC) (n: 13, 3%). The total number of respondents per WHO region and their characteristics regarding age, sex and semester are summarized in Table 1.

Table 1. Number of respondents and their characteristics regarding age, sex and semester in total and per WHO region.

	AFR	**AMR**	**EMR**	**EUR**	**SEAR**	**WPR**	**No answer**	**Total**
Sex (n=501)								
Female	4 (19%)	55 (60%)	29 (53%)	193 (66%)	7 (100%)	13 (42%)	0 (0%)	301 (60%)
Male	17(81%)	37 (40%)	26 (47%)	99 (34%)	0 (0%)	17 (55%)	0 (0%)	196 (39%)
Unknown	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (3%)	3 (100%)	4 (1%)
Age (n=501)	Mean: 23 Min: 20 Max: 26	Mean: 22 Min: 17 Max: 41	Mean: 22 Min: 17 Max: 27	Mean: 23 Min: 18 Max:38	Mean: 20 Min: 19 Max: 21	Mean: 21 Min: 18 Max: 27	Mean: 23 Min: 17 Max: 41	
15-20 years	1 (5%)	21 (23%)	8 (15%)	33 (11%)	4 (57%)	12 (39%)	0 (0%)	79 (16%)
21-25 years	17 (81%)	63 (68%)	44 (80%)	218 (75%)	3 (43%)	18 (58%)	0 (0%)	363 (72%)
26-30 years	1 (5%)	4 (4%)	3 (5%)	34 (12%)	0 (0%)	1 (3%)	0 (0%)	43 (9%)
31-35 years	0 (0%)	1 (1%)	0 (0%)	4 (1%)	0 (0%)	0 (0%)	0 (0%)	5 (1%)
36-40 years	0 (0%)	0 (0%)	0 (0%)	2 (1%)	0 (0%)	0 (0%)	0 (0%)	2 (0%)
41-45 years	0 (0%)	1 (1%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (0%)
Unknown	2 (10)	2 (2%)	0 (0%)	1 (0%)	0 (0%)	0 (0%)	3 (100%)	8 (2%)
Semester (n=501)	Mean: 6 Min: 1 Max: 12	Mean:6-7 Min:1 Max:13	Mean: 7 Min: 1 Max:14	Mean: 7 Min: 1 Max: 12	Mean:7 Min: 1 Max:9	Mean: 6 Min:1 Max:16	Mean: 6 Min: 1 Max: 16	
1-4	5 (24%)	22 (24%)	9 (16%)	63 (22%)	1 (14%)	14 (45%)	0 (0%)	114 (23%)
5- 8	5 (24%)	43 (47%)	19 (35%)	113 (39%)	5 (71%)	8 (26%)	0 (0%)	193 (39%)
9-12	5 (24%)	21 (23%)	20 (36%)	92 (32%)	1 (14%)	5 (16%)	0 (0%)	144 (29%)
Unknown	6 (29%)	6 (7%)	7 (13%)	24 (8%)	0 (0%)	4 (13%)	3 (100%)	50 (10%)
Total	21 (4%)	92 (18%)	55 (11%)	292 (58%)	7 (1%)	31 (6%)	3 (1%)	501 (100%)

Respondents view on the current AR situation

A majority of the respondents perceived AR to be a big (40%) or moderate (47 %) problem in their country today. The percentage of students ranking AR as a big problem was significantly lower in high income countries (33%, 95% CI 28% 38%) compared to the other World Bank income groups (52%, 95% CI 44%-59%). As seen in figure 4, the majority of the respondents in EUR and EMR considered AR to be a moderate problem, whereas the majority of students studying in AFR, AMR and SEAR rated AR to be a big problem. Which semester the respondent attended did not seem to affect the result, nor did the respondents gender.

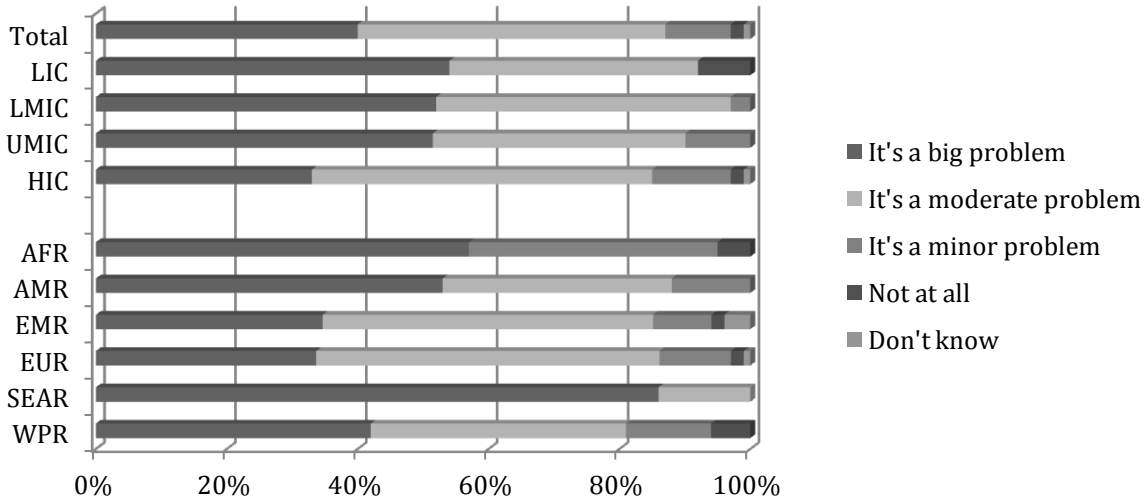

Figure 3. Perception of the severity of AR in the respondents own country, analyzed per World Bank region and WHO region, n: 498.

World Bank regions: Low Income Countries (LIC), Lower Middle Income Countries (LMIC), Upper Middle Income Countries (UMIC), High Income Countries (HIC). European regions: African Region (AFR), Region of the Americas (AMR), Eastern Mediterranean Region (EMR), European Region (EUR), South East Asian Region (SEAR), West Pacific Region (WPR).

Of the respondents stating that AR was a problem in their country the majority (44%) considered the problem to be most serious in hospitals while 185 respondents (38%) believed that the problem was equally serious in hospitals as in primary care. Only 55 respondents (11%) considered AR to be the most serious in primary care. The percentage of students ranking AR as a problem most severe in hospitals was significantly higher in high income countries (49%, 95% CI 44%-55%) compared to the other World Bank income groups (31%, 95% CI 29%-43%). Gender or semester attended in school did not seem to affect the results.

When asked if AR affected different social groups differently 182 respondents (36%) agreed that it did and that the most serious consequences occurred in low-resource populations, whilst 151 respondents (30%) did not believe that social group mattered. The percentage of students who did not considering socioeconomic status a factor of importance was significantly higher in high income countries (36%, 95% CI 31%-41%) compared to the other World Bank income groups (20%, 95% CI 14%-26%), who foremost believed low-resource populations were affected negatively. As shown in figure 4 respondents studying in HIC was the only group where the majority (36%) answered that social group did not matter. When comparing responses from different WHO regions the EUR was the only one where the majority (38%) answered that social group did not matter.

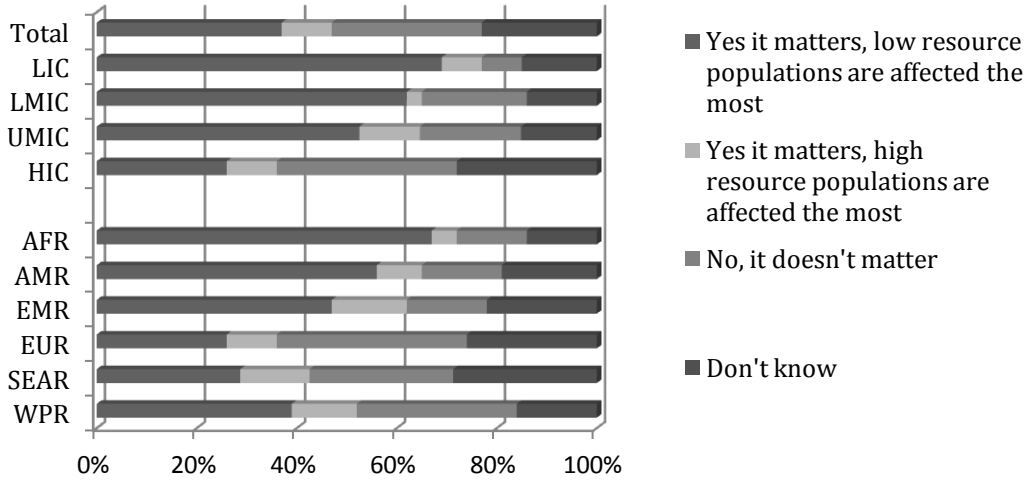

Figure 4: Perception of the influence of socioeconomic status on the effects of AR. Analyzed per World Bank region and WHO region (n: 496). 5 did not answer the question or state which country they study in.

When analyzing according to semesters the percentage of students considering socioeconomic factors important was significantly higher in student at the end of their education, term 9-12 (48%, 95% CI 40%-56%), who believed low-resource populations were affected negatively, compared to students in the beginning or middle of their education, term 1-8 (32%, 95% CI 27%-37%). The differences between semesters are illustrated in figure 5.

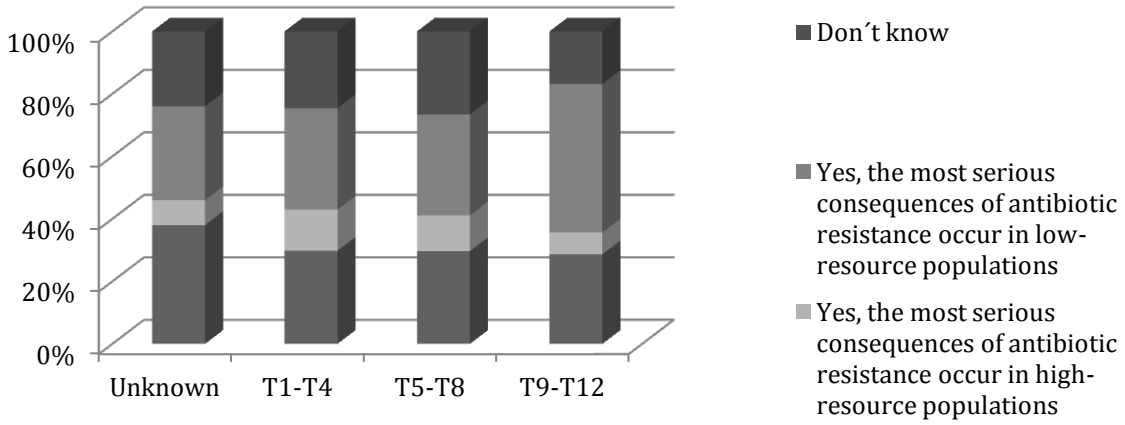

Figure 5. Students' view of the importance of social group when facing the risk of serious complications caused by AR. 2 did not answer the question (n: 499).

Reasons for antibiotic resistance situation

Of the multiple choices presented in the questionnaire as possible reasons for the development of antibiotic resistance, two reasons dominated "Inappropriate prescribing habits of antibiotics by doctors (antibiotic use for non-bacterial causes; use of to broad spectrum antibiotic etc)" and "Patients self-medicating with antibiotics without a doctor's consultation or prescription". The same two reasons dominated when participants were asked to rank their answers. The results of the two questions are shown in figure 6.

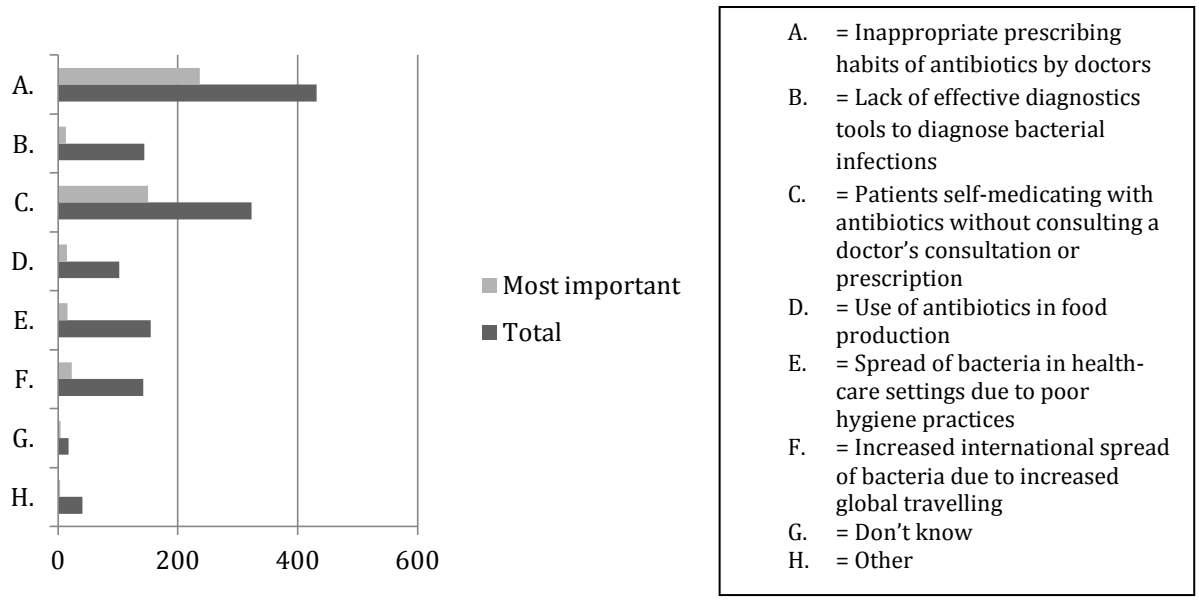

Figure 6. Respondents perception factors/most important factor causing AR. Forty-one (8%) of the students had chosen "others" as one of their three factors, out of which 24 (5%) wrote "patient not following doctor's prescription". Two did not answer the question, 15 had chosen more than 3 options and were excluded, 38 (8%) did not rank their answers (total n: 484, most important n: 499).

Regardless WHO region, World Bank region, gender or semester the two most important reasons for the development of antibiotic resistance where the same as stated above. A difference was detected between respondents from different countries depending on whether or not antibiotics could be bought with or without a prescription. In both groups the most common reasons for the development of AR was the same as stated above. However a significant difference was detected between students from countries where antibiotics can be bought without a prescription, and students from countries where a prescription is needed. The percentage of students who considered inappropriate prescribing habits by doctors as the most important reason was significantly higher in students from countries where a prescription is needed to purchase antibiotics (57%, 95% CI 51%-63%) compared to students from countries where antibiotics can be purchased without a prescription (31%, 95% CI 29%-43%). The reversed was seen when analyzing the students who answered that patients self-medicating was the most important factor. The percentage of students who considered patients self-medicating to be the most important reason was significantly higher in students from countries where no prescription is needed to purchase antibiotics (49%, 95% CI 42%-56%) compared to students from countries where a prescription is needed (15%, 95% CI 11%-19%).

Future antibiotic resistance situation and perceived impact on respondent's future work as physician

The participants were asked if they thought the consequences of AR would affect their future work as doctors when caring for patients. The majority (50%) answered "often" which was defined as 11-40% of patients with bacterial infections, 118 (24%) answered "occasionally" which was defined as 5-10% of patients with bacterial infections, 110 (22%) answered "very often" which was defined as more than 40% of patients with bacterial infections, 14 (3%) answered "rarely" defined as less than 5% of patients with bacterial infections, and 7 (1%) answered "not at all", (n: 499). The percentage of students who answered that the consequences of antibiotic resistance will affect their future work as a doctor when caring for patients with

bacterial infections was significantly lower in high income countries (18%, 95% CI 14%-22%) compared to the other World Bank income groups (30%, 95% CI 23%-37%).

The majority of the students (40%) thought that they as newly licensed doctors would gain the most information about proper use of antibiotics through available standard treatment guidelines, 119 (24%) from their medical education, and 111 (23%) from laboratory reports about the current bacterial resistance patterns. Besides these three answers no other stood out as more popular than the others. These results were not affected by gender, semester or what WHO and World Bank region the participant lived in,

The participants were asked to rank what the three most important factors are to reduce the development of AR in their country, and to also mark the one factors they considered the most important. The results of the two questions are shown in Figure 7.

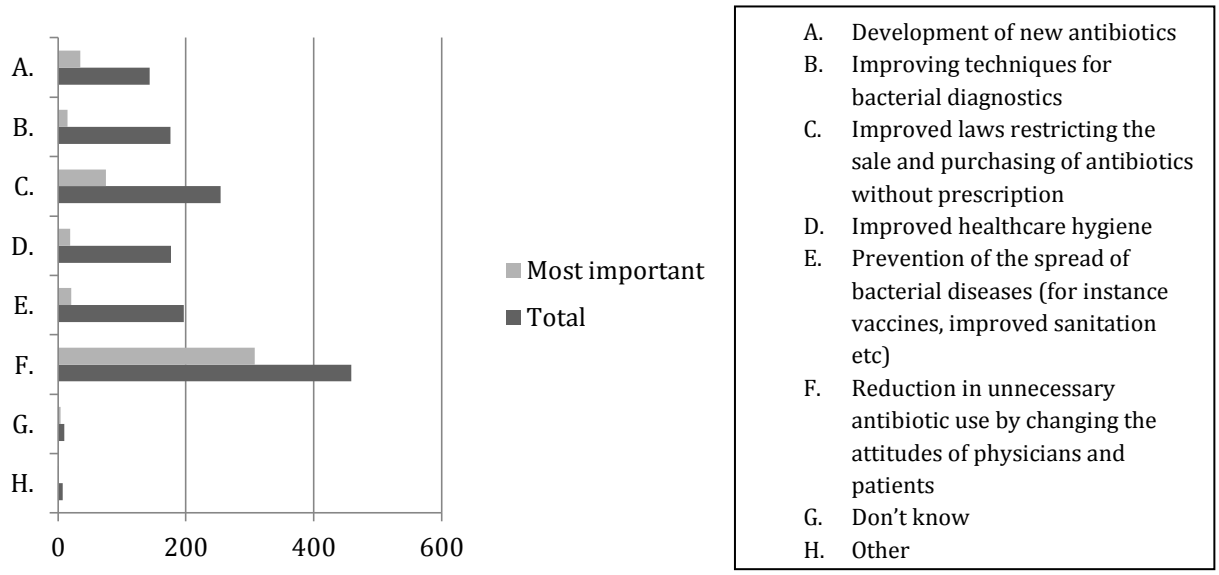

Figure 7. Factors perceived as important/the factor most important to reduce AR in the respondents own country. 7 (1%) chose to answer "other" when stating three most important factors, out of which 5 wrote "reduction of antibiotics in food production". 20 (4%) did not rank their answers, 4 did not answer the two questions, 9 had chosen more than 3 options and were excluded, total n: 488, most important n: 498.

All WHO regions agreed that "reduction in unnecessary antibiotic use by changing the attitudes of physicians and patients" was the most important factor to reduce the development of AR. As the second most important factor the participants chose "improved laws restricting the sale and purchasing of antibiotics without prescription. When analyzing the results according to the economic status of the country all groups agreed that "reduction in unnecessary antibiotic use by changing the attitudes of physicians and patients" was the most important factor. The percentage of students who considered improved laws, restricting the sale and purchasing of antibiotics without prescription, as the most important intervention was significantly higher in students studying from middle income countries (34%, 95% CI 26%-42%) compared to students from other WHO Bank income groups (7%, 95% CI 4%-10%).Semester and gender of the participant did not affect the results.

The majority of the students (47%) did not believe today's research will be sufficient to meet the future needs for new antibiotics, (33%) stated that they didn't know, and only 97 (20%) answered that they believed today's research is enough.

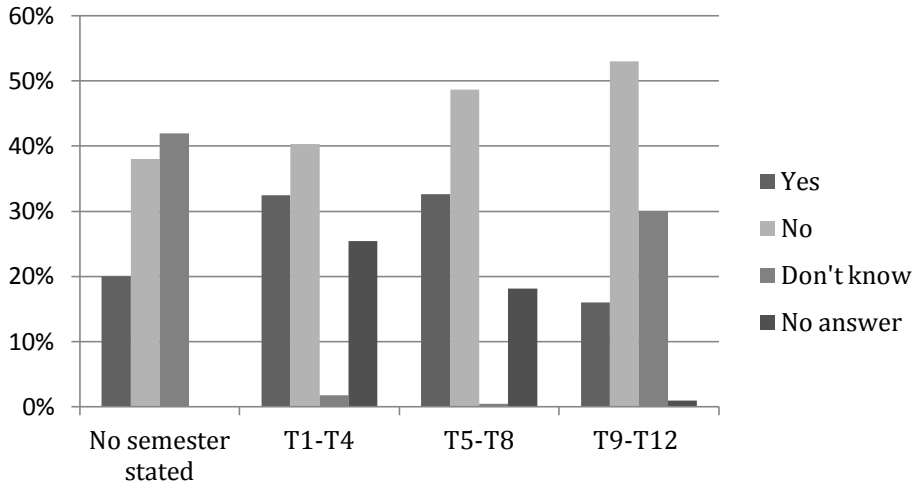

Figure 8. Students beliefs about the sufficiency of research today. 5 did not answer the question (n: 496).

The participants were asked to rank the three most important stakeholders that according to them had the biggest responsibility of reducing the development of AR. The list consisted of 8 groups with the possibility of adding other stakeholders. The results are shown in Figure 9.

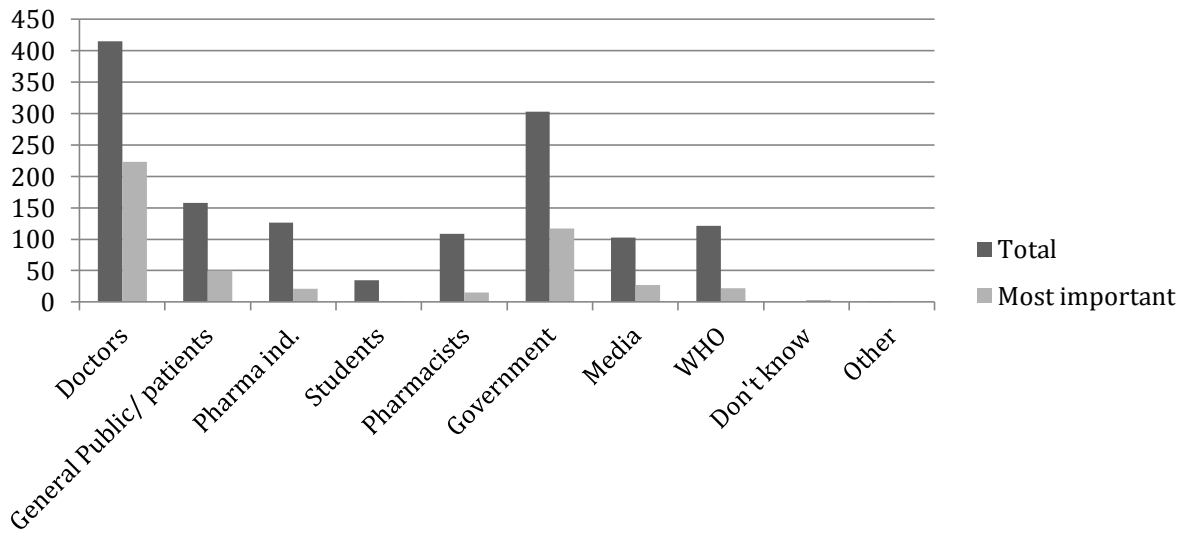

Figure 9. Stakeholder's responsibility to reduce AR. "Other" represents 1 person who added universities to the list of stakeholders with responsibilities. 3 did not answer the first question (the 3 most important stakeholders) and 2 did not answer the second question (the most important stakeholder), 19 (4%) did not rank their answers, 6 students chose more than 3 answers and were therefore excluded (total n: 492, most important n: 499).

The role of medical students

The majority of the respondents (55%) believed that students can contribute to the work being done to control antibiotic resistance, 148 (30%) answered that students could contribute if they were better trained, 76 (15%) answered that students could contribute marginally. No difference was detectable between genders or semester.

Discussion

The main findings of this study are that (i) students from high income countries do not consider AR as big of a problem as students from low and middle income countries do (ii) students view on factors important to reduce AR in their own country reflects the policies on antibiotic sales and purchase in their country (iii) medical students believe that doctors and governments are the two main stakeholders responsible for reducing AR (iv) medical students believe that they can contribute to the work being done to reduce AR (v) finally, medical students believe that they will be able to rely on available standard treatment guidelines, laboratory reports about the current bacterial resistance patterns, and the knowledge they gain during their medical education as the main sources of information on prudent use of antibiotics and AR.

Few studies have targeted students' views on antibiotic resistance which makes it difficult to compare our results to other studies. The studies conducted by Minen et al. and Pulcini et al. both have targeted medical students and junior doctors as their study population, but performed their studies in geographically distinct areas (16, 17). Minens study took place at an urban medical school in the northeast of the United States the Pulcini study took place in two hospitals, one in France and one in Scotland. The choice of surveying "a smaller and more homogenous population" is of course of importance to the study result. However, part of the problem regarding AR is that, even though the problem is global and affects us all, it is still not being addressed in all countries. This study therefore attempts to obtain a wider perspective by including medical students on all continents.

AR has become one of the most important topics in global health and by many it is considered one of the main threats to public health. This study shows that medical students are well aware of this issue, but that there is a difference in how AR is perceived depending on what region you live in. There is a significant difference between students from low and middle income countries, who consider AR to be a bigger problem in their own country compared to what students living in high income countries estimate the problem of AR to be in their county. This is partly due to an uneven global distribution of resources. For large populations in low and middle income countries (LMIC) the consequences of AR are augmented by a general high burden of bacterial diseases, more challenged healthcare and laboratory systems, and limited access to the newer antibiotic classes with activity against multi-resistant bacteria. However, this study shows that there is also a significant difference in attitude towards the severity of AR when students were asked to answer questions about the future. Students from high income countries showed once more that they do not considering AR to be as big of a problem as students from low and middle income countries. The fact that high income countries have had enough resources to keep resistance at a distance seems to have caused a false sense of security. Cars and Nordberg points out that antibiotic resistant bacteria spread with considerable ease regardless of national borders, meaning that high income countries won't be able to escape the effects of AR (25). If left without functional antibiotics it will become both difficult and expensive, for all countries, including high income countries, to deal with the results of bacterial infections. In order to prevent the development of AR countries most likely will have to cooperate with each other and start working across borders. This of course means that resources will have to be moved from HIC to LMIC if the efforts to decrease AR are going to be successful. It is therefore unfortunate to see that it is the future physicians of high income countries that do not appreciate the magnitude of this problem. Interventions targeting AR also needs to be develop to better suit low-resource healthcare systems with a general high burden of bacterial diseases.

This study shows that medical students' view of the main reasons for the development of AR is connected to health care laws and policies on antibiotic sales and purchase in the country they live and work in. The majority of respondents from countries where antibiotics can be

purchased without a prescription considered patients self-medicating as the most important reason for the development of antibiotic resistance. In addition they considered improved laws, restricting the sale and purchasing of antibiotics without prescription, as the most important intervention. Respondents from countries where a prescription is necessary in order to buy antibiotics more often considered inappropriate prescribing habits of antibiotics by doctors as the most important reason. The most important intervention was considered to be reducing unnecessary antibiotic use by changing the attitudes of physicians and patients. Numerous of times it has been pointed out that physicians' prescribing habits have great impact on the development of AR (2, 9, 11, 13, 26, 27, 28). This study shows that medical students are well aware of this. Medical students are aware of the effects of government influence on healthcare and that they expect and demand governments to take on the responsibility for the health of their nations' population. This survey also shows that medical students understand their own responsibility as future healthcare workers to take part in reducing the development of AR. Medical students should therefore be seen as a resource to use when dealing with AR. However, in order to be able to contribute to a change students requests the help of available information in the form of guidelines and laboratory reports as well as an education that prepares them for what they will have to face as physicians. In a joint project by Discipline of Social and Administrative Pharmacy (DSAP), School of Pharmaceutical Sciences, Universiti Sains Malaysia and Action on Antibiotic Resistance (ReAct) the conclusion was that education on AR should be introduced early in training, medical school, residency and fellowship programs, and that attention needs to be directed towards the appropriate use of antibiotics in medical and pharmacy colleges (14).

Humphreys et al. and Ibia et al. found that medical students knowledge on antibiotics and AR was limited (18, 19) which is a risk for inappropriate prescribing of antibiotics. This implies that the education, that medical students rely upon, is not sufficient enough to teach students how to use antibiotics in a responsible way. According to Ibia et al. students and junior doctors often seek information from older colleagues instead (19). Unfortunately there are studies that indicate that physicians' knowledge about proper use of antibiotics and AR are also insufficient. Hussain et al. concluded that the use of new agents to treat MRSA seldom were in accordance with the European or US licensed indications and often inappropriate and sometimes even dangerous (29). In addition Cadieux et al. found that inappropriate antibiotic prescribing behavior tended to increase with time in practice and concludes that physicians who have been in practice longer and physicians with high-volume practices also tended to prescribe antibiotics inappropriately (30). This means that older colleagues despite appearances might not be the best source of information for newly licensed doctors. This might not be a reflection of poor knowledge, but rather that there are other aspects that physicians are forced to take into consideration when prescribing antibiotics and that these aspects tend to be prioritized over the risk of AR development. Gould et al. states that the following factors are of suboptimal prescribing of antibiotics: imperfect knowledge, diagnostic uncertainty, fear of complications, fear of disciplinary cases, communicative aspects, perceived patient expectations, financial interests (26). These factors influence physicians' treatment choices, making AR a neglected factor. This is highly understandable, but should not be passed on to the next generation of doctors. Medical schools need to teach their students the importance of prudent use of antibiotics at an early stage and to convene that appropriate use of antibiotic resistance protects the interests of the global population.

Study limitations:

To our knowledge there have been few studies focusing on medical students. The few we have found have been restricted to medical students in selected schools in high income countries. We have had the ambition to not restrict ourselves to only high income countries because we believe that this is a global problem and that all populations therefore are of interest. This study has a

number of limitations, out of which the most important one is caused by our selection of population. The population chosen were medical students belonging to the international medical student organization, IFMSA. The IFMSA is one of the largest student organizations of the world and is present in close to 100 countries. The organization communicates through emailing lists where close to 6000 students are registered on the general list alone. Our survey has been distributed via these emailing lists and therefore the response rate is under 10 %. The response rate from the General Assembly is somewhat higher, 22%. Secondly, since the organization main field is public health there is possible that the students in the organization are more aware and concerned about this issue than medical students in general. Since the survey was optional there is also the risk that the students who chose to answer the survey are more concerned about AR.

Conclusion

AR has proven to be a great challenge to public health. Studies show that physicians are aware of the problem, but many do not consider AR to be a problem at their own clinic and in their own practice. Prescription of antibiotics can always be motivated by claiming that it is in the patients' best interest and thereby justify not taking AR into consideration when prescribing antibiotics. Many interventions with the aim to decrease AR has been targeting hospitals and practicing doctors, yet there are still huge gaps in the medical curriculum concerning AR. Instead medical students educate themselves by copying older colleagues, without knowing if they have the competence necessary to make appropriate prescribing decisions. In order to decrease unnecessary prescribing medical students need to be targeted repeatedly during their education, and be thought the value of prescribing antibiotics with caution. By not increasing the efforts to teach medical students to avoid overusing antibiotics in the attempts to treat patients, we are putting future patients' health at risk. A decade ago medicine was restrained by the fact that many of the treatments and medical instruments we use today had not yet been invented; however there was never a discussion of not offering patients every treatment available. Modern medicine has different challenges to tackle. It is no longer a main issue of non existing treatment options, instead the difficulties lies in how to distribute the resources both globally and over time. In order to manage the development of AR there has to be a paradigm shift within the field of medicine. Medical student has to be thought how to use resources not only to treat patients of the present but to also be able to treat patients in the future. This study shows that medical students are willing to take on this challenge.

Disclosure statements

According to the author of this paper medical students offer a great resource when dealing with AR. Medical students have a good understanding of the risk of contributing to AR by prescribing antibiotics irrationally in their future clinical work. They also show a good understanding of their potential of being a part of the solution and a willingness to contribute. However, they do acknowledge the need for more education about this problem, and there is therefore an urgent need to improve education on antibiotic treatment and AR in medical curricula, and that this issue is addressed repeatedly during their medical training.

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Appendix 1:

Students' view on antibiotic resistance

This study aims to investigate the attitude of medical students on antibiotic resistance. It is conducted by the international network ReAct - Action on Antibiotic Resistance (www.reactgroup.org) through me, Cecilia Kållberg, member of IFMSA-Sweden.

The survey consists of three sections with a total of 24 questions and takes about 10 minutes. Participation is anonymous, and data will be analyzed according to differences between countries, not schools.

If you want more information about the study please contact Cecilia Kållberg: ceciliakallberg@gmail.com

or Liselotte Diaz Högberg, Deputy Director of ReAct: liselotte.hogberg@medsci.uu.se

When you've filled in the survey please hand it back to me, Cecilia Kållberg or to the NMO-president of IFMSA-Sweden.

Thank you for participating!

Background information about you

1. Age: _____
2. Gender: Male ☐ Female ☐
3. School: _____
4. Educational program:

   ☐ Medicine ☐ Other, please specify: _____
5. Semester: _____
6. NMO: _____
7. Standing committee:_____
8. Have you attended a session or workshop about antibiotic resistance during this GA?

   Yes ☐ No ☐
9. Country: _____
10. Is your school a public or private school? Public ☐ Private ☐

Please continue

A: YOUR VIEWS ON THE ANTIBIOTIC RESISTANCE SITUATION TODAY

1. **Do you think that antibiotic resistance is a problem in your country today?**

   ☐ Not at all

   ☐ It's a minor problem

   ☐ It's a moderate problem

   ☐ It's a big problem

   If you have indicated that it is a problem (minor/moderate/big, where do you consider it to be most serious?

   ☐ In hospitals

   ☐ In primary care

   ☐ Equally serious in both

   ☐ Don't know

2. **In your view, is antibiotic resistance being discussed in your country today? By whom? Tick all that apply.**

   ☐ Not at all

   ☐ By your medical faculty

   ☐ Amongst health personal

   ☐ General media

   ☐ Policymakers

   ☐ The public

   ☐ Don't know

3. **What do you believe are the 3 main reasons for the development of antibiotic resistance in your country? Choose 3 alternatives and rank them 1-3, number 1 being the most important. Write the numbers in the squares.**

   ☐ Inappropriate prescribing habits of antibiotics by doctors (antibiotic use for non-bacterial causes; use of to broad spectrum antibiotic etc)

   ☐ Lack of effective diagnostic tools to diagnose bacterial infections

   ☐ Patients self-medicating with antibiotics without a doctor's consultation or prescription

   ☐ Use of antibiotics in food production

   ☐ Spread of bacteria in health-care settings due to poor hygiene practices

☐ Increased international spread of bacteria due to increased global travelling

☐ Other, please specify: _____

☐ Don´t know

4. **Do you think people's socioeconomic status have an effect on the risk of being affected by antibiotic resistance in your country?**

☐ No, it does not matter

☐ Yes, the most serious consequences of antibiotic resistance occur in low-resource populations

☐ Yes, the most serious consequences of antibiotic resistance occur in high-resource populations

☐ Don´t know

5. **Is it possible to buy antibiotics without a prescription in your country?**

Yes ☐ No ☐ Don't know ☐

B. YOUR VIEW ON THE FUTURE SITUATION AND POSSIBLE SOLUTIONS

1. **In a 10-year perspective, do you think the consequences of antibiotic resistance will affect your future work as a doctor when caring for patients with bacterial infections?**

☐ Not at all

☐ Rarely (< 5% of my patients with bacterial diseases)

☐ Occasionally (in 5-10% of my patients with bacterial diseases)

☐ Often (in 11-40% of my patients with bacterial diseases)

☐ Very often (in > 41% of my patients with bacterial diseases

If you have indicated that it will affect your work – what do you expect will be the greatest problem? Tick one.

☐ More expensive treatment for patients

☐ Fewer treatment alternatives

☐ Increased morbidity due to untreatable bacterial infections

☐ Increased spread of communicable diseases due to untreatable infections

☐ Don´t know

2. **What do you believe are the 3 most important factors to reduce the development of antibiotic resistance in your country? Choose 3 alternatives and rank them 1-3, number 1 being the most important. Write the numbers in the squares.**

- ☐ Development of new antibiotics
- ☐ Improving techniques for bacterial diagnostics
- ☐ Improved laws restricting the sale and purchasing of antibiotics without prescription
- ☐ Improved healthcare hygiene
- ☐ Prevention of the spread of bacterial diseases (for instance vaccines, improved sanitation etc)
- ☐ Reduction in unnecessary antibiotic use by changing the attitudes of physicians and patients
- ☐ Other, please specify:
- ☐ Don't know

3. **Do you believe today's research will be sufficient to meet the future needs for new antibiotics?**

Yes ☐ No ☐ Don't know ☐

4. **Who do you believe should be responsible for reducing the development of antibiotic resistance? Choose 3 alternatives and rank them 1-3, number 1 being the most important. Write the numbers in the squares.**

- ☐ Government
- ☐ Media
- ☐ WHO
- ☐ Doctors
- ☐ Pharmacists
- ☐ Pharmaceutical industry
- ☐ Students
- ☐ General public/patients
- ☐ Other _____

5. **Where do you think you as a newly licensed doctor will gain most of your knowledge about proper use of antibiotics (10-year perspective)? Choose one answer.**

- ☐ The medical education you received at school
- ☐ Available standard treatment guidelines
- ☐ More senior colleagues
- ☐ Laboratory reports about the current bacterial resistance patterns
- ☐ Pharmaceutical companies
- ☐ Other, please specify: _____

C. WAYS OF REACHING OUT TO STUDENTS

1. **Do you think students <u>can</u> contribute to the work being done to control antibiotic resistance?**

- ☐ Not at all
- ☐ Marginally
- ☐ Maybe, if we were to be better trained
- ☐ Yes, we can contribute

2. **In what form would you like to obtain information/education about antibiotic resistance and rational use of antibiotics? (Please mark your top 3 choices).**

- ☐ Through the medical education system
- ☐ Internet based information centers
- ☐ Online courses about proper antibiotic usage
- ☐ Education for hospital staff at each hospital
- ☐ National guidelines
- ☐ From more senior colleagues
- ☐ Other, please specify: _____

3. **If you had access to an internet based education program about antibiotic resistance would you be interested in using this program? (1= not interested, 5= yes I would be very interested)**

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

4. **What would you like to see on such internet based education program (Please mark your top 3 choices).**

- ☐ Access to information and articles about antibiotic resistance
- ☐ Access to a web based self study course about antibiotic resistance
- ☐ Information about meetings taking place around the world and outcome from these
- ☐ Possibilities to upload information about your own antibiotic resistance project
- ☐ A newsletter
- ☐ Information about international projects students can work in
- ☐ Contact information to doctors and others working with this issue
- ☐ Access to material that could be printed out and distributed
- ☐ Forum possibilities
- ☐ Other_____

If you have any other comments, please write them here:

_____
_____
_____

Thank you for participating!