



D1.1 State of the art and needs analysis on AMR training in Europe

A review of antimicrobial resistance education for healthcare professionals across six countries of the European Union: Greece, Hungary, Italy, Lithuania, Portugal, and Spain

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- **ABBREVIATIONS**

AMR	Antimicrobial resistance
AMS	Antimicrobial stewardship
CDC	Centre for Disease Control
CPD	Continuous Professional Development
CRE	Carbapenemase-producing-enterobacteriaceae
ECDC	European Centre for Disease Control
EU	European Union
HCWs	Healthcare workers
HAI	Healthcare-associated infection
IPC	Infection prevention and control
NAP	National Action Plan
WHO	World Health Organization

Disclaimer: Although best efforts were made to identify all relevant research and publications, the authors acknowledge that some relevant content may be omitted from this document.

1. EXECUTIVE SUMMARY

○ Introduction

Antimicrobial resistance (AMR) is a significant threat to humans, animals and the environment, demanding urgent and coordinated efforts for mitigation. Education of healthcare workers (HCWs) is a key strategy for improving prescribing and reducing AMR promoting practices in human healthcare settings. Education of healthcare workers should, therefore, be considered a priority for national and international policy makers, including within the EU.

○ Rationale

The EU aims to enhance antimicrobial stewardship and considers education of healthcare professionals as a key component within the Council recommendation *Stepping up EU actions to combat antimicrobial resistance in a One Health approach*¹. Current evidence from the ECDC suggests that Greece, Hungary and Italy have the lowest rates of knowledge on AMR amongst healthcare workers². This report aims to outline key areas to enhance education within these countries and the EU, in order to improve the standard of AMR management across the European region.

○ Key findings

- Current AMR education lacks the integration of One Health approaches in general healthcare education at all levels, from undergraduate to postgraduate and continuing education.
- AMR continues to be a growing problem within the target countries (Greece, Hungary, Italy, Lithuania, Portugal, Spain), with a need to enhance all AMR stewardship interventions.
- The implementation of educational aspects of the AMR national action plans is currently low, and requires concerted effort, including resource mobilisation.
- The target countries currently lack standardised national education for healthcare professionals on recommended topics for AMR education. This issue exists within undergraduate, postgraduate and continuous education and requires systematic action to improve this.
- There are disparities in educational availability on AMR across the various healthcare workers. Efforts to address health professionals such as pharmacists, nurses, and laboratory technicians remain spontaneous and rely heavily on on-the-job experience.

○ Recommendations

This report has identified key recommendations for the selected countries to enhance their AMR education programmes and opportunities for international shared learning based on successes in each area.

- Ensure mobilisation of national structures to support planning for AMR education at a national level.
target countries should ensure structures for AMR educational planning exist at the national level and are in line with recommendations for national structures to implement AMR education.
- Ensure healthcare worker education on AMR includes One Health approaches.
It is important that future improvements in AMR education are considerate of a One Health approach and integrate it within educational programmes.
- Develop educational curricula which are tailored to specific health professional roles, educational level and need.
It is important that education on AMR is specific to the varying educational needs of healthcare professions, and that education is available for all healthcare workers on AMR, not only those who prescribe antimicrobial agents.
- Consider shared learning opportunities between and amongst countries within the EU to strengthen education provision and ensure an approach that Leaves No One Behind².
There is large variation in AMR educational levels amongst the EU Member States. As the EU action plan considers that the EU could become a best practice example in antimicrobial stewardship, it is important that Member States work in collaboration to support educational development across the region: sharing experience, knowledge and best practice examples.

○ Conclusion

Although significant achievements have been made in the development of education for AMR, within the countries discussed there is a need for strategic educational development for all healthcare professionals to achieve universal improvements in knowledge. AMR requires cross-border responses and AMR education for healthcare professionals is a key component of achieving antimicrobial stewardship and protecting modern medicine.

1. INTRODUCTION

Antimicrobial resistance poses a significant threat to healthcare, healthcare systems and the environment globally, with AMR requiring an international approach. Therefore, this issue requires a strategic approach to reduce the impact of AMR and protect antimicrobials for generations to come. The first objective of the WHO Global Action Plan on Antimicrobial Resistance⁴ suggests targeting this global issue by raising awareness, improving education and increasing training availability for health workers to improve their management of antimicrobials, including prescribing and dispensing behaviours.

AMR occurs when bacteria, viruses, fungi, and parasites develop mechanisms to minimise the effect of antimicrobials designed to treat the infections they cause. Whilst this is a naturally occurring phenomenon, the overuse and misuse of antimicrobials accelerates the process⁵. The major drivers behind the occurrence and spread of AMR are the use of antimicrobial agents and the transmission of antimicrobial-resistant microorganisms between humans, animals, and the environment. Prudent antimicrobial use and high standards of IPC in all healthcare settings are, therefore, the cornerstones of an effective response to AMR.

Comprehensive AMR education is crucial to curb its spread and preserve antibiotic effectiveness. EU Directive 2005/36/EC³ streamlines healthcare qualification recognition among Member States⁶. Hence, there is a need for all EU policymakers to ensure AMR education is consistent within the EU, to maintain an aligned approach in all EU settings. The ECDC *Survey of healthcare workers' knowledge, attitudes and behaviours in the EU/EEA*³ assessed the identified countries within the European Union where knowledge of AMR was lowest. Given the need for a cross-border response to AMR⁷, this *Gaps in AMR education for health* report will contribute to the development of effective strategies to improve AMR education for the health workforce in countries which were identified as requiring enhancement in AMR knowledge.

ECDC KNOWLEDGE SCORE (7 KNOWLEDGE QUESTIONS*)	
COUNTRIES	RESULTS (OUT OF 7)
EU average	6.35
Spain	6.49
Portugal	6.33
Italy	6.19

ECDC KNOWLEDGE SCORE (7 KNOWLEDGE QUESTIONS*)	
COUNTRIES	RESULTS (OUT OF 7)
Hungary	6.02
Greece	6.17
Lithuania	6.59

Figure 1. ECDC barometer results: country results ³ *

**ECDC's seven knowledge questions (True/False): Antibiotics are effective against viruses, Antibiotics are effective against cold and flu, Taking antibiotics has associated side effects or risks such as diarrhoea, colitis, allergies, Unnecessary use of antibiotics makes them become ineffective, Healthy people can carry antibiotic resistant bacteria, Antibiotic resistant bacteria can spread from person to person, Every person treated with antibiotics is at an increased risk of antibiotic resistant infection.*

The report targetes on current AMR educational practices in Greece, Hungary, Italy, Lithuania, Portugal, and Spain, and provides recommendations for opportunities to enhance ad develop future educational planning.

2. MAIN OBJECTIVES OF THE REPORT

In order to inform future educational planning and workforce development for healthcare professionals, this report aims to:

- Provide an overview of the current situation of AMR education for the health workforce in Greece, Hungary, Italy, Lithuania, Portugal, and Spain.
- Identify the gaps and needs in AMR education for medical doctors, nurses, pharmacists, and health management professionals.
- Provide recommendations for policymakers and healthcare professionals aiming to develop effective strategies for improving AMR education for the health workforce. These recommendations aim to support a 'Leave No One Behind' approach³ to enhancing the health workforce's knowledge and skills in AMR prevention and control.
- It is highly important to note that educational initiatives should be combined as part of a comprehensive approach including strategic interventions, communications, surveillance and other core implementation strategies⁵.

3. SITUATIONAL OVERVIEW

3.1. The AMR threat in Europe

The diminishing effectiveness of antibiotics presents a serious concern for healthcare systems within the European Union (EU). In the EU/EEA, AMR causes an estimated 33,000 deaths per year⁸. Unless further action is taken, AMR could cause 390,000 deaths per year in Europe by 2050 and 10 million deaths globally - more than the expected deaths caused by cancer and diabetes combined. Global increases in healthcare costs are also expected due to the impact of AMR in the healthcare sector, which may range from \$300 billion to 1 trillion annually⁹.

In the EU/EEA, nearly 40% of the health burden of AMR is caused by infections from bacteria resistant to last-resort antibiotics (colistin, carbapenems, third and fourth-generation cephalosporins, and others) which are used to treat infections resulting from bacteria that are resistant to common antibiotics⁸. When these antibiotics are no longer effective, some infections may be impossible to treat.

Implementing robust educational initiatives for professionals across various sectors involved in AMR could enhance their knowledge and expertise in effectively combating antimicrobial resistance.

3.2. AMR as a priority for EU policymakers

AMR is a global issue that requires consideration across all aspects of the One Health approach in order to prevent its continued development. It is a multi-dimensional concern that affects humans, animals, and the environment simultaneously, requiring a holistic and trans-sectoral One Health approach⁵. The COVID-19 pandemic has shown the potential risks from infections without treatments and the benefits of a global approach in combating these threats¹⁰. Similarly, AMR should be considered a priority for policymakers as tackling it requires strategic approaches and planning that is considerate of a multitude of sectors¹¹.

Given the role of AMR education in antimicrobial stewardship, there is a need for decision-makers to ensure that this area is sufficiently addressed to meet overall goals in AMR prevention. As education and training are objectives recommended within national action plans, it is essential that high level decision makers at regional and national level are aware of the current situation of AMR education for healthcare workers.

Despite the existence of education and training priorities in action plans across Europe, there is a significant lack of implementation of components relating to AMR within healthcare worker education and training ¹².

The EU Council recommendation on stepping up actions to combat AMR ¹⁰ suggests that continuous education programmes and curricula should include mandatory cross-sectoral training and competence courses on AMR for healthcare workers¹. This further expresses that a national continuing education programme and curriculum be available for healthcare workers: namely medicine, nursing, midwifery, pharmacy, and dentistry. Therefore, policymakers and leaders within the European region should strive to ensure national education on AMR and antimicrobial stewardship (AMS) exists for healthcare workers.

3.3. The importance of healthcare worker education as a key component of Antimicrobial Stewardship

Education has been recognised as a key component of healthcare workforce development strategies. While addressing the global shortage in healthcare workers, there has been an increased emphasis on ensuring quality education is available to support this developing workforce ¹³. In order to improve the quality of care and address some of these workforce shortages, models of healthcare have moved from medical staff-focused to multidisciplinary approaches, with an increased emphasis placed particularly on pharmacists, nurses and other registered HCWs.¹⁴

Similarly, AMS is moving from prescriber-focused to broader HCW involvement.^{15,16} As such it is imperative that healthcare worker education aligns with this change and considers education of all HCWs to support evidence-based solutions and effective AMS in practice⁷. Providing national AMR education for HCWs in both continuous education and standard curricula is recommended for all countries within the European Union (EU).¹

Despite education being considered a key factor in combating AMR, there are significant gaps in the implementation of AMR education and training as shown in Figure 2.

Figure 1.4. National action plans for AMR are usually well-developed but there are significant gaps in policy implementation

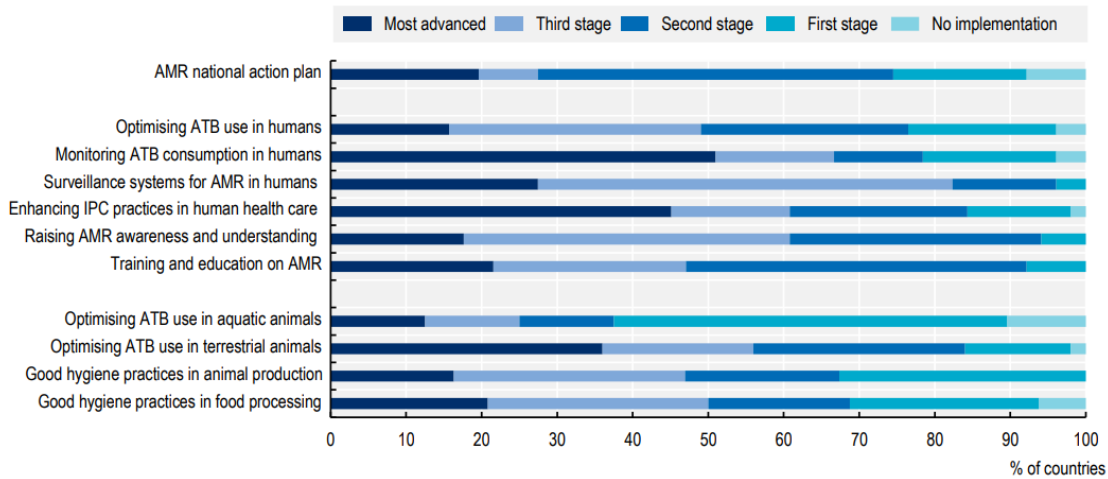


Figure 2. Current gaps in NAP for AMR implementation within OECD countries¹³

3.4. Current knowledge on AMR of healthcare professionals in Europe

In 2019, the European Centre for Disease Prevention and Control (ECDC) conducted a survey² on the attitudes and behaviours of healthcare professionals towards antibiotic use and AMR. Although the results suggested that HCW’s knowledge of the assessed topics was high (Annex 1), there were key considerations identified that can help us better understand the situation of AMR education in Europe.

Medical doctors achieved the highest score of all the professionals participating in the survey. This may be attributable to a combination of factors such as differences in education and training, and professional responsibility for managing and treating infections². There is a need for further exploration and research on this topic.

The survey also detected wide variations between countries in terms of capabilities, opportunities and motivation, as well as the practices of healthcare workers, which may also be related to different educational approaches. Hence, there is a need to continue with actions to raise awareness among healthcare professionals about AMR and to design interventions to improve practice.

3.5. Current standards for AMR education and training

The WHO’s *Health workers education and training on antimicrobial resistance: curricula guide*¹⁶ outlines core areas that are suggested to frame the education of healthcare workers, with

specific consideration for varying professional groups. This document considers various professional groupings based largely on their involvement in activities relating to AMR, such as prescribing, management and supportive roles (Figure 3).

Although a variety of online materials exist for AMR education in Europe, such as those produced by the ECDC (Annex 1) and other European based institutions, there are no European standards agreed for what should be included in the curriculum for healthcare worker education on AMR. The EU's *A European One Health Action Plan against Antimicrobial Resistance (AMR)*⁷ stresses the need for education in the fight against AMR.

Fig. 1. Matrix model for antimicrobial resistance curricula

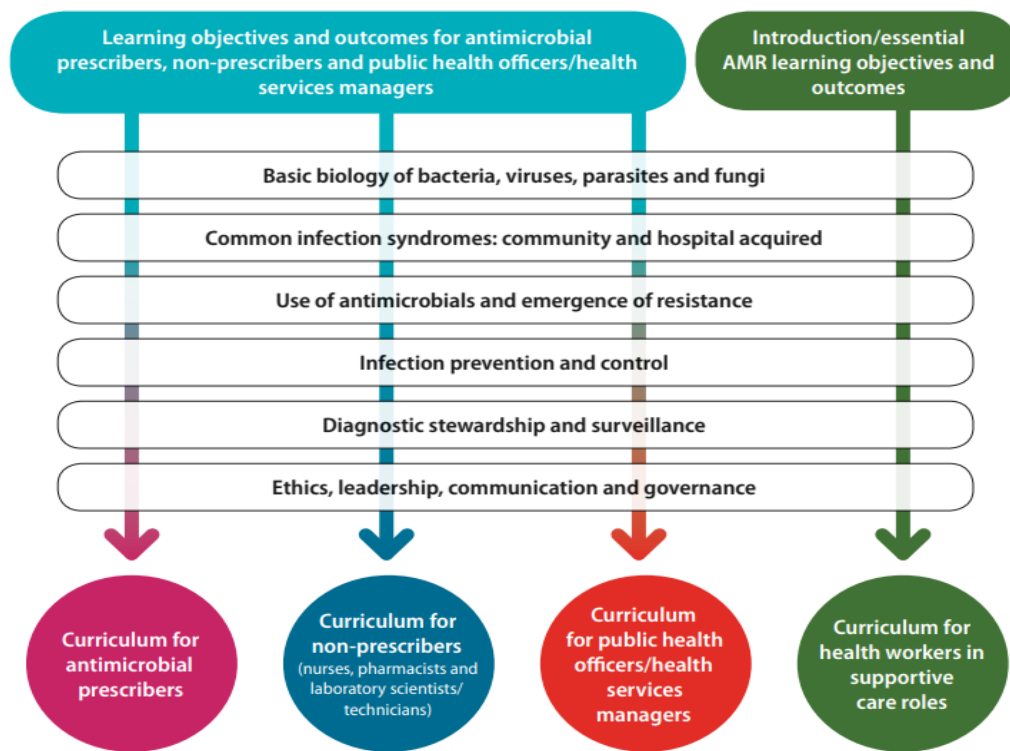


Figure 3. WHO matrix model for antimicrobial resistance curricula²⁰

4. OVERALL REPORT FINDINGS

The following reviews of educational content on AMR were carried out by desk review from March 2023 to July 2023. Desk reviews were carried out by the relevant partner institution in each country as listed above. Searches were in both English and the local language of each country. Although no defined search terms were set, agreement was made by each country partner to research education and training for pre-graduate, postgraduate and continuing education, utilising the common local terminology and terms outlined within the WHO guidance¹⁶. Although best efforts were made to identify all relevant research and publications, the authors acknowledge that some relevant content may be omitted from this document.

The following section presents synthesised results from all the countries, which aim to inform considerations for wider approaches to AMR education.

4.1. The current AMR situation in assessed countries

Greece

AMR rates across Greece remain problematic despite recent efforts to curb their development. According to the most recent figures, 40% of all infections were caused by the 12 antibiotic-superbug combinations assessed by the OECD in 2023¹². Greece ranks third in antibiotic consumption per capita among the 27 European Member States. According to the latest report of the European Surveillance of Antimicrobial Consumption Network (ESAC-Net), for 2021 the total consumption (community and hospital sector) of antibacterials for systemic use in Greece was 23.5 Defined Daily Doses/1000 Inhabitants/Day (DID)¹⁷.

Greece is the highest consumer of carbapenems and second in consumption of polymyxins in the EU/EEA, in notable parallel to the observed increased resistance rates¹⁸. More than half of infections caused by *Klebsiella pneumoniae* in Greece are projected to be carbapenem resistant by 2035¹². As previously mentioned the OECD also found that Italy and Greece have the highest burden of deaths and DALYs due to resistant infections¹².

Hungary

AMR in Hungary is a continued challenge to the healthcare system. According to the OECD, rates of *Pseudomonas aeruginosa* were particularly high in Hungary when compared to other countries, particularly within the EU¹². Hungary has seen significant rates of antibiotic

prescribing with large amounts of systemic antibiotics, however low rates of systemic antibiotics prescribed within long-term care settings. In 2019, AMR deaths in Hungary accounted for a higher percentage of total deaths than digestive, neurological and respiratory diseases.¹⁹

Italy

The current burden of AMR across Italy has had a significant impact on the healthcare system. The OECD suggests that Italy is estimated to incur the greatest losses in per capita labour market output¹². They also concluded that Italy and Greece have the highest burden of deaths and DALYs due to resistant infections. Recently, Italy has seen an increase in rates of priority pathogens. Rates of methicillin-resistant *Staphylococcus aureus* (MRSA), the most common Healthcare-associated infection (HAI) in the EU, currently exceed 25% in Italy¹⁷. This is despite having set a target of reducing the prevalence of methicillin-resistant *S.aureus* in blood isolates by more than 10% in their 2017-2020 National Action Plan²⁰ It has been estimated that investment in modelled interventions can curb this issue. Italy is amongst the top three EU countries estimated to have the highest AMR mortality rate by 2050 if no significant action is taken to curb the spread¹².

Lithuania

Since 2019 patterns of key resistance markers have increased in Lithuania¹². Without strong policy actions, resistance in fluoroquinolone-resistant *Escherichia coli* and carbapenem-resistant *P. aeruginosa* are expected to grow substantially, threatening key treatments. A study by de Figueiredo et al. found Lithuania had the lowest agreement with the statement 'vaccinations are important' of all studied countries, despite these being a key tool against AMR development²¹. Lithuania has seen the impact of AMR in practice with a multisite outbreak of CRE within hospitals reported across 2019-2020²².

Spain

Although efforts have been made in Spain to strengthen the healthcare system against AMR, and ECDC recommendations on methods to reduce antibiotic use have been taken into account in the development of training, the latest data show that Spain remains one of the OECD countries with the highest consumption of antibiotics¹². Spain has a long history of conducting point prevalence surveys and therefore data on HAI and AMR in hospital settings is well documented, which may facilitate strong targeted interventions on AMR²³.

Rates of fluoroquinolone-resistant *Acinetobacter baumannii* and fluoroquinolone-resistant *E. coli* are predicted to significantly increase in Spain by 2035 if no action is taken¹². In 2023, Spain hosts the EU Council presidency and has expressed this as an opportunity to further progress on AMR and One Health ²⁴.

Portugal

Similarly to other Southern European countries, Portugal has trends in AMR which are generally higher than the EU average¹⁷. In Portugal, in 2019 alone, there were 2,200 deaths attributable directly to AMR and 9,400 deaths in some way associated with AMR. According to the Institute for Health Metrics and Evaluation, Portugal has the 45th lowest age-standardised mortality rate per 100,000 population associated with AMR out of 204 countries²⁸. Portugal is currently estimated to risk the greatest reductions in life expectancy across the region as a result of AMR development²⁵.

In 2019, deaths from AMR ranked higher than respiratory disorders, diabetes and kidney disease¹⁹. Portugal made significant efforts to maintain AMR systems and prevent disruption during the COVID-19 pandemic by supporting hospitals with AMR teams¹². Comparing the use of antibiotics in human and veterinary medicine in Portugal, two-thirds of antibiotics consumption happens in the context of veterinary medicine, while the remaining one-third of all antibiotics are used on humans²⁶.

4.2. AMR education as a national priority

Antimicrobial resistance has been considered as a policy consideration for all countries reviewed. 5 of the 6 countries have a National Action Plan (NAP) for AMR in place, and Hungary is currently undertaking plans for NAP development. Hungary concurrently has a national IPC action plan which includes recommendations for AMS training. Within the available country NAPs, all include criteria for education and training as recommended within the strategic objectives set out by the WHO⁴. However, there is a need for strengthened implementation of these objectives and to integrate more concerted considerations for healthcare workers who are not prescribers. A number of NAPs have goals specifically for pharmacists and medical doctors but fail to adequately consider education for other healthcare professionals. For national education programs to effectively cater to the workforce's needs, it's crucial that they receive thorough attention and consideration at the policy level.

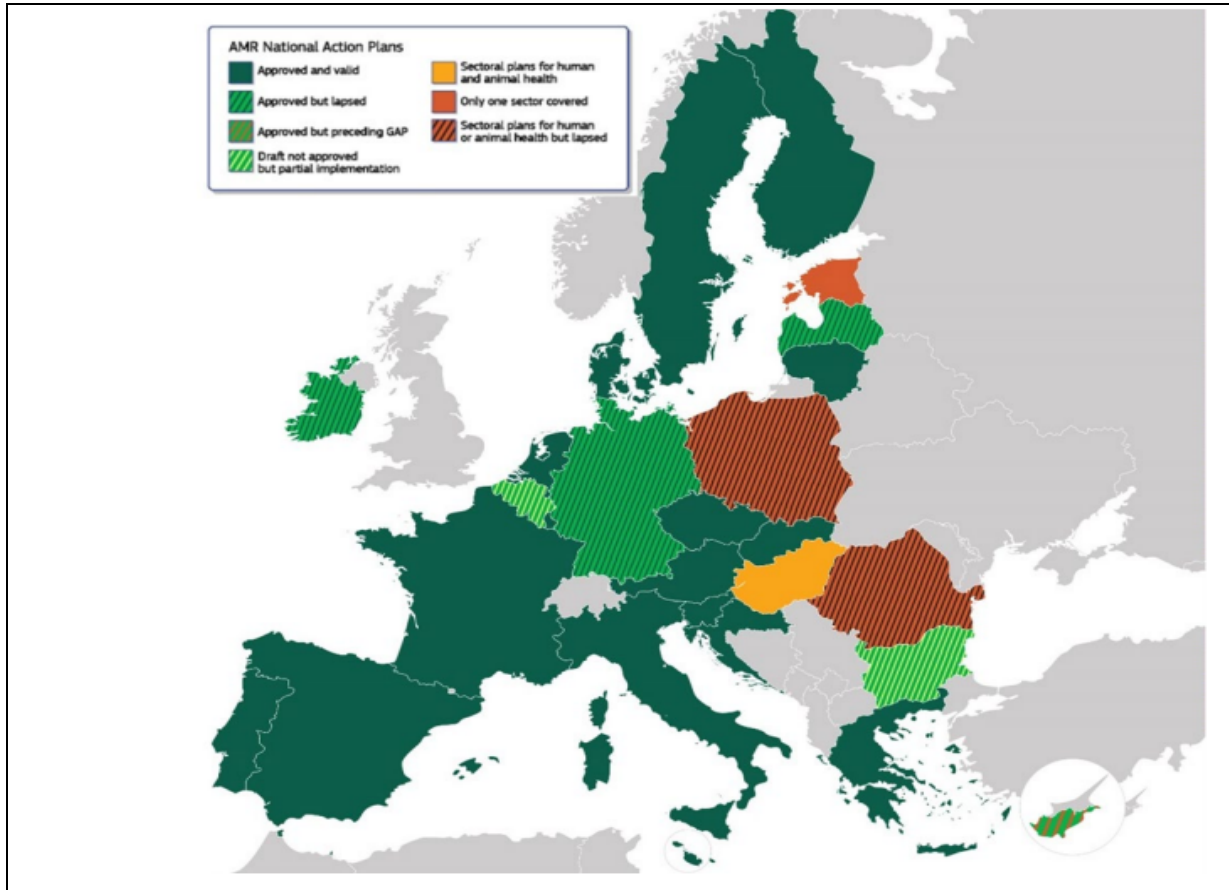


Figure 4. ‘Status of One Health AMR Naps across the EU in 2021, ECDC²⁶

Although budgetary planning for NAP implementation is considered critical, there is currently insufficient evidence of clear budget availability for AMR education in the researched countries to implement NAP actions. Education and training require sufficient investment to enhance and develop, and this is a key component that should be strengthened by national decision-makers in each of the countries. In Italy, there is a clear recommendation for enhancing resources for HCW education for AMR, and planning for this implementation is ongoing.

The WHO-supported evidence for policy brief *Preventing antimicrobial resistance and promoting appropriate antimicrobial use in inpatient healthcare in Greece*²⁷, suggests “Implementation of postgraduate educational programmes for health-care workers on prudent antimicrobial use and infection control in the hospital setting” as a key option for addressing the high rates of AMR and HAI across the country’s healthcare system. However it is currently unclear from the available evidence if this has been implemented at a national level.

The ECDC conducted supportive missions to Italy²⁸ and Spain²³ to support the implementation of Council recommendations relating to AMR. These missions highlighted the lack of national approaches to AMR education and training.

Given the important role education plays in AMS and the need for strategic implementation and resources, it is important that AMR education and training be considered at the national level, and be prioritised. A lack of AMR strategies has significant economic impact on healthcare systems and implementing AMR strategies effectively, including education, has the potential to deliver cost savings in this area¹².

4.3. Organisation of AMR education

Across the countries assessed it is clear that AMR stewardship is a growing priority which has been successful in improving AMR education and training within specific locations. Improvements and initiatives exist in all countries which could be exemplary for use in future initiatives or expanded to form national programs within the country.

However, despite the work conducted there is a consistent need to consider AMR education at national level, and to standardise AMR education requirements for all healthcare workers¹⁶. All countries involved in the review have national governance structures for pre-graduate education, with a number of these structures including external quality assurance agencies (Lithuania, Spain). These institutions presently have a limited involvement in AMR education. In Italy, although systematic objectives for other medical topics exist, this does not currently include any mandatory credits on AMR.

Regional and institutional variance in education provision exist across the countries studied and currently there are no agreed educational objectives for this topic for each of the healthcare professional groups. Specific countries have commenced the development and implementation of national training for healthcare workers on this topic. In Spain, regional differences exist based on governance structures, however, a dedicated base training module exists on AMR for pharmacists and medical staff. Lithuania has enhanced efforts to standardise education by introducing a module for all healthcare workers in 2022 titled *Rational prescription and use of antimicrobial drugs*.

National standardisation of healthcare professional education objectives is vital to ensure uniformity in approaches to AMR, including prescribing and dispensing practices, and patient education. These can be aligned with individual professional needs, such as those outlined in the aforementioned AMR competencies for healthcare workers¹⁶

4.4. Current AMR Education

Within each country there are existing AMR modules and training courses available for healthcare professionals. These vary widely across the studied countries, however, there is a common theme of a larger availability of resources for medical doctors and minimal resources for healthcare workers not involved in prescribing or dispensing of antimicrobials.

Considering the key role nurses have in patient education, IPC and medication distribution in hospitals, the lack of education for this group is concerning. Similarly, the lack of educational emphasis on healthcare managers is worrisome, considering their role in leadership, management, and establishing effective antimicrobial resistance (AMR) structures.

Furthermore, there is a noticeable gap in understanding the current education of other healthcare workers (HCWs), including laboratory technicians, who are specifically mentioned in the WHO competency framework¹⁶. While many national action plans in various countries recognize this problem and stress the importance of expanding education for a broader range of healthcare professionals, these intentions are not consistently reflected in current implementation efforts.

Although it is recognised that advancements in AMR education exist in all reviewed countries, at present no country meets all educational competency domains for AMR as set by the WHO. Furthermore, there is no clear standardised curriculum for any HCW group which includes all recommended components (Figure. 3.). One Health education for healthcare workers is generally absent and healthcare professionals from the focus countries report low levels of awareness for this key approach to AMS²⁹(Figure 4).

Undergraduate education

Within undergraduate education, it is acknowledged that there are compulsory modules for medical practitioners in all countries on microbiology and related infectious diseases. This appears limited to medical staff and there is less available evidence on the extent of this for other healthcare professionals such as nurses. It is important to consider that while knowledge of microbiology is helpful in understanding AMR, it alone does not meet the competencies suggested for healthcare workers. There is a need for additional specific educational domains such as those outlined in Figure 4. e.g. understanding the development and main causes of AMR.

Within the review it was noted that a number of independent national health societies have engaged in the creation of educational material for AMR. In Greece this has been a common mode of AMR education.

Greece

Currently, undergraduate education in Greece on AMR for healthcare workers is not mandated by any national body. As such, individual universities offer courses relating to the topic for medical students but these have no specific parameters to adhere to and therefore vary greatly amongst universities. A large number of these are often optional for students to complete. Internal studies have shown low knowledge of AMR and rational antibiotic use in medical students in Greece, highlighting the inefficiencies in AMR education available for this group^{30,31}.

The situation for pharmacy students in Greece is currently similar to that of medical students. Universities offer courses in microbiology which cover aspects of AMR³². Due to legislation restricting dispensing of antibiotics in Greece, pharmacists are aware of the need to restrict access to antibiotics but there is no evidence available suggesting a formal national curriculum exists regarding this.

Coverage of AMR in Nursing education in Greece is limited and does not currently meet the recommendations set out by the WHO³³.

In Greece, a number of universities report including One Health within their undergraduate curricula^{34,35}, however, although enhanced One Health approaches are included within the National Action Plan³⁶, there remains no standardised education on this topic to date. National Prevention Plan 2020-2025, titled *Measures to Counter Antimicrobial Resistance*, identifies the mandatory objective for all Regions to "promote the dissemination of knowledge, skills, and awareness that foster the adoption of measures to counter AMR in schools at all levels, university courses, and continuous professional development"³⁶.

Hungary

According to the available evidence, there is currently no standardised curricula for healthcare workers relating to AMR or AMS. There are a limited number of educational modules available on IPC, however, these are currently optional³⁷. Interestingly, courses on this content are mandatory for veterinary students³⁸. In 2018 the Ministry of Human Capacities of Hungary commissioned an evidence for policy brief which outlined opportunities and advantages of enhancing undergraduate, and postgraduate education in Hungary. However, to date this recommendation has not been implemented at a policy level.

The results of a representative European survey of final-year medical trainees suggest that Hungarian medical students do not feel that the knowledge they obtained in medical school prepared them to prescribe antibiotics properly³⁹.

One Health approaches are currently absent from healthcare worker education. Despite calls for this to be integrated into undergraduate curricula, to date, this has not been implemented³⁷.

Italy

In Italy, there are many educational or training initiatives on AMR²⁸, but few are centralised or coordinated at the national level. For medical students, topics related to AMR and the appropriate use of antibiotics are covered in different parts of the curriculum, such as microbiology and infectious diseases courses, but not necessarily as a dedicated subject. The depth of these topics depends on the awareness and willingness of individual institutions, therefore, it is difficult to ascertain the level of AMR education provided.

The National Prevention Plan 2020-2025, connected to the new National Plan to Counter Antimicrobial Resistance 2022-2025, responds to the need to address the training of healthcare professionals from a One Health perspective. Prior to this, pre- and postgraduate training for healthcare professionals were focused exclusively on human-related topics. Specifically, Program Predefined 10 of the National Prevention Plan 2020-2025, titled *Measures to Counter Antimicrobial Resistance*, identifies the mandatory objective for all regions in Italy to "promote the dissemination of knowledge, skills, and awareness that foster the adoption of measures to counter AMR in schools at all levels, university courses, and continuous professional development"²⁰.

Lithuania

Similar to education on AMR available in the other assessed countries, healthcare worker education on AMR is not standardised and focuses predominantly on microbiology and infectious disease management (Table, 2). Within universities, courses are offered on these topics which help to build healthcare workers' knowledge on AMR.

Efforts have been made to address education gaps for nurses, pharmacists and doctors, although these have predominantly focused on continuous professional education and graduate education (as described below) and have not been integrated into undergraduate curricula. An updated national action plan on AMR is not currently available, with the current version targeting (2017-2022)⁴⁰.

Table 2. Subjects with AMR content in undergraduate university education in Lithuania

	University Degree in Medicine	University Degree in Nursing	University Degree in Pharmacy	University Degree in Public Health
Lithuanian University of Health Sciences (LSMU) ⁴¹	Pharmacology, Microbiology, Infectious Diseases,	Microbiology, Pharmacology, Nursing Prescribing and	Microbiology, Pharmacology ⁴⁴	Microbiology and Immunology, Infectious Diseases ⁴⁵

	Clinical Laboratory Diagnostics ⁴²	Therapeutics, Public Health ⁴³		
Vilnius University	General Microbiology and Immunology, Medical Microbiology, Pharmacology, Clinical Pharmacology, ⁴⁶	Pharmacology ⁴⁷	Microbiology, Pharmacology ⁴⁸	Microbiology and Immunology, Epidemiology ⁴⁹
Klaipeda University	N/A	Microbiology, Pharmacology ⁵⁰	N/A	Microbiology, infectious diseases and their prevention ⁵¹

The One Health perspective is still an evolving approach in the training of health professionals in Lithuania. The education in Lithuania for healthcare professionals, particularly nurses, physicians, pharmacists and health managers, does not integrate a One Health Approach.

Portugal

Medical education in Portugal currently has structures to facilitate standardisation. Medical school deans integrate the *Conselho de Escolas Médicas Portuguesas* (National Medical Schools Council), which establishes common agreements on undergraduate training.⁵² This Council recently reformulated a document that establishes a *Reflection on the profile of the newly graduated physician in Portugal*: this does not include specific training objectives on antimicrobials. However, all medical schools have learning units on microbiology and in this context antimicrobial resistance is addressed. Currently, this education does not seem sufficient to build medical knowledge of AMR. A 2018 study that included medical students from several European countries, through a self-reported survey, showed that Portuguese medical students had the lowest score in the percentage of readiness to prescribe antibiotics, with only 54.8% saying they were prepared⁵³.

For nurses, there is no reference to antibiotic resistance and antibiotic stewardship in any of the nursing curricula consulted for this study⁵⁴. Curricular units related to pharmacology, microbiology and public health are often taught in a single semester and are frequently grouped together. This practice, while addressing a broad spectrum of medications nurses will encounter in their future professional roles, doesn't allocate room for discussing pressing issues stemming from the improper use of antibiotics. Additionally, it fails to emphasize the vital role nurses play in mitigating resistance linked to antibiotic usage.

A Study addressing AMR knowledge among nurses, showed nurses focused on the need for continuing education, as well as the inclusion of this topic in basic education⁵⁴. Although this data is from 2018, it is highly likely that the landscape of undergraduate and postgraduate nursing education has not changed significantly. Additionally, first-year nursing students in Portugal found that although 60% of respondents thought that antibiotics were only effective against bacteria, 32% thought that antibiotics should be prescribed for viral illnesses, suggesting an urgent need for further education in this area⁵⁵.

The research assessed did not find any compulsory education for undergraduate pharmacy students, despite their important role in AMR prevention and a number of national initiatives to improve community antibiotic use utilising community pharmacists.

Spain

The Ministry of Education and Professional Training and the National Agency for Quality Assessment and Accreditation establish the competencies and general objectives that curricula must meet in order to obtain accreditation and official recognition of university degrees, as established in Royal Decree 822/2021.

Within the assessed curricula offered by the leading universities in Spain, students were offered similar courses to the other reviewed countries: microbiology, pharmacology, infectious disease management (Table 3). These modules are mandatory and contribute towards meeting the curriculum requirements as suggested by the WHO³³. However there is a need to further expand and standardise the information within the modules to ensure that this content covers all core competencies required for healthcare professionals. The review noted that there was less availability of this education for nurses, however, basic education is available.

Table 3. Subjects with AMR content in undergraduate university education in Spain.

	University Degree in Medicine	University Degree in Nursing	University Degree in Pharmacy	Master's Degree in Health Management
Complutense University of Madrid	Preventive medicine and Public Health, Pharmacology, Microbiology ⁵⁶	Microbiology, Pharmacology, Nursing Prescribing and Therapeutics, Public Health ⁵⁷	Microbiology, Clinical Microbiology, Pharmacology ⁵⁸	N/A
University of Barcelona	General Pharmacology, Medical Microbiology, Infectious Diseases, Preventive Medicine, Public Health and Applied Statistics, Clinical Pharmacology ⁵⁹	Clinical Pharmacology, Microbiology applied to nursing (elective) ⁶⁰	Microbiology I, Microbiology II, General Pharmacology, Pharmacology & Therapeutics I, Pharmacology & Therapeutics II ⁶¹	There are no related subjects ⁶²⁻⁶⁴
University of Salamanca	General pharmacology, Medical microbiology, Infectious diseases and applied microbiology, Clinical pharmacology, Preventive medicine, public health and health management ⁶⁵	Pharmacology ⁶⁶	Microbiology I, Microbiology II, Pharmacology I, Pharmacology II, Pharmacology III ⁶⁷	There are no related subjects ⁶⁸
University of Granada	Basic Pharmacology, Medical Microbiology and Parasitology, Preventive Medicine and Public Health, Clinical Pharmacology ⁶⁹	Pharmacology, Fundamentals for the prevention and care of patients with infectious and immunological diseases ⁷⁰	Microbiology I, Microbiology II, Pharmacology I, Pharmacology II, Clinical Microbiology and Parasitology, Pharmacology III, Public Health ⁷¹	N/A

Table 3. Subjects with AMR content in undergraduate university education in Spain. (continued)

	University Degree in Medicine	University Degree in Nursing	University Degree in Pharmacy	Master's Degree in Health Management
University of Valencia	Epidemiology and Preventive Medicine, Medical Microbiology and Parasitology, General and Organ and Systems Pharmacology, Infectious Diseases and Clinical Microbiology, Clinical Pharmacology, Microbiological Basis of Antimicrobial Therapy (elective), Pharmacoepidemiology (elective) ⁷²	Pharmacology ⁷³	Microbiology, Pharmacology I, Pharmacology II, Pharmacoepidemiology (elective), Clinical Microbiology (elective) ⁷⁴	Preventive medicine, epidemiology, disease and injury prevention ⁷⁵
University of Seville	Medical and clinical pharmacology, Medical and clinical microbiology, Medical pathology of infectious diseases and the immune system, Primary care ⁷⁶	Clinical pharmacology ⁷⁷	Microbiology extension, Applied microbiology, Pharmacology and pharmacotherapy I, Pharmacology and pharmacotherapy II, Pharmacology and pharmacotherapy III and clinical pharmacy, Microbiology and clinical parasitology ⁷⁸	N/A

Postgraduate education

Postgraduate education for AMR is extremely important for shaping AMR programmes, developing AMR awareness in leadership, and increasing overall knowledge of AMR within the healthcare workforce⁷⁹. Despite this, postgraduate education requires large investment across the studied countries in order to strengthen the goals of this resource and to ensure it reaches the entirety of the healthcare workforce. It is important to note that the lack of postgraduate education poses a larger question on the basis of AMR continuous professional development, given the lack of educational opportunities to train leaders in AMR. Further research into the number of healthcare workers participating in postgraduate education in other countries may be needed to better understand this component of AMR education in the studied countries.

Greece

Within the review conducted of education in Greece, a small number of universities offer stand-alone modules (not specifically postgraduate education) which may address components of AMR. However, the majority of education currently available on AMR focuses on continuous professional development training rather than standardised educational courses. This poses a concern for the availability of skills to conduct and provide these training courses, given the lack of educational availability in AMR overall for healthcare managers.

Hungary

Despite recommendations to strengthen both undergraduate and postgraduate education on AMR within the recent WHO policy brief on AMR, there continues to be a lack of postgraduate resources on AMR in Hungary. Efforts to increase professionals' knowledge on AMR have been focused on continuous professional development (as expanded in this section) but this has seen a lack of similar improvement within postgraduate curricula. Target groups have been identified by national institutions within the aforementioned policy brief and development of postgraduate education in these areas may be beneficial for enhancing AMR education in Hungary. Infection prevention and control related courses at universities for training any allied-health professionals are not standardised.

Italy

There are no specific postgraduate or routine courses on AMR and antimicrobial stewardship for physicians, similarly, there are no regular educational programs for other healthcare professionals. Within the creation of the Italian National Action Plan, the ECDC provided a series of recommendations, compiled in a final document. Among the priority recommendations, there is a need to strengthen the training of graduates, students, and professionals involved in the prevention of healthcare-associated infections and antimicrobial stewardship. It also emphasises the importance of increasing the number of specialised hospital professionals in

infection prevention and control and antimicrobial resistance management, as well as allocating more resources for their training.

It is important to note that in Italy there is no specific educational path for infection, prevention and control professionals, which is traditionally offered within postgraduate education in other European countries.

Lithuania

As in other countries, the focus of education on AMR is predominantly aimed at in-service professionals through workplace training and continuous professional development training, rather than within postgraduate settings.

Portugal

Several scattered initiatives have been described in the literature to improve physicians' continuing professional education, all of which are optional and voluntary. Portuguese universities have their own courses on antimicrobial agents, which usually have a section dedicated to antimicrobial stewardship, but these are voluntary courses with a limited number of places, which limits their use and dissemination^{80,81}.

Spain

There is a wide range of postgraduate courses aimed at Spanish healthcare professionals who wish to broaden their knowledge of AMR. Courses such as masters degrees and university diplomas on the topic exist. The majority of these courses are aimed at general healthcare professionals. Areas of WHO recommended education represented in these courses include antimicrobial prescribing optimisation, HCAI training and a minimal focus on One Health (including within CPD training). Education at postgraduate level offers the opportunity for healthcare professionals at all disciplines to expand their knowledge on AMR and AMS.

Continuous education

Continuous healthcare education is the component of education across all countries where most advancements have been made in providing education and training to HCW. All countries assessed offer at least some form of continuous education ranging from in-hospital sessions to formal courses developed by national societies. The delivery of these courses varies, including online modality.

Greece

Within Greece it is acknowledged that the majority of training materials on AMR are developed by national medical societies. Regional campaigns attempting to improve AMR management have been carried out, such as the campaign targeting both public and primary care physicians in the region of Corinth in Peloponnese, Greece in 2009–10, with the aim to improve antibiotic use supported by local universities⁸².

In an attempt to strengthen continuous education for AMR, the Greek government launched a mandate in 2014 that all hospitals must provide education on AMR and IPC to newly qualified nurses and doctors upon hiring them⁸³. However, there is currently a lack of monitoring of this mandate and as such the level of implementation of this programme is unclear.

Hungary

There are no mandatory training schedules on AMR in Hungary. However, it is mandated that Institutional Infection Control and Antibiotics Committees organise in-house initial and in-service training for prescribing physicians at least annually. These should cover infection control, diagnostic stewardship and antibiotic stewardship, as well as bedside practical training and education on the microbiological diagnosis of infections and antimicrobial drug therapy, with feedback on the effectiveness of the training. The rate of implementation of this goal is currently unclear.

Additionally, elective continuous professional development training is available. However, the current completion rates and motivation of HCW to complete these courses is unclear.

Italy

The National Prevention Plan 2020-2025, connected to the new National Plan to Counter Antimicrobial Resistance 2022-2025, responds to the need to address the training of healthcare professionals from a One Health perspective. Prior to this, pre- and postgraduate training for healthcare professionals was focused exclusively on human-related topics. Specifically, Program Predefined 10 of the National Prevention Plan 2020-2025, titled *Measures to Counter Antimicrobial Resistance*, identifies the mandatory objective for all Regions to "promote the dissemination of knowledge, skills, and awareness that foster the adoption of measures to counter AMR in schools at all levels, university courses, and continuous professional development"⁸⁴.

Recently, the new National Recovery and Resilience Plan has included investments for the "Development of technical, professional, digital, and managerial skills of healthcare personnel." This includes the launch of an extraordinary training plan on healthcare associated infections for all healthcare and non-healthcare personnel in hospitals, with approximately 150,000 participants by the end of 2024 and an additional approximately 140,000 by June 2026. Training for operators in all appropriate areas on AMR and healthcare-associated infections prevention

will be promoted, including topics such as vaccinations as a primary tool to reduce antibiotic use, the phenomenon of AMR, biosafety, animal welfare in farming, and monitoring in environmental matters⁸⁵.

Lithuania

The compulsory programme of continuing medical education (CME) *Rational prescription and use of antimicrobial drugs* was introduced on November 1st, 2020. However, AMR training in Lithuania has been targeted at doctors and pharmacists. There is currently no mandatory training for nurses or healthcare managers on AMR or related topics. A training course on AMR in dental practice has been specifically developed and is currently available. Similar courses have been developed by other professional societies such as for pharmacists, pharmacy assistants, and doctors.

Spain

There is a growing focus on AMR training across Spain at present. The majority of the training activities available for HCWs within Spain are non-university training courses. These courses are aimed at general healthcare profiles. It is noted that of the courses found in this review, there was a distinctly lower availability of courses focused at the primary healthcare sector (just 11% of those found).

Within this review, it was acknowledged that medical and pharmacy graduates in Spain receive basic and mandatory training in AMR. To a lesser extent, nursing graduates also receive basic training in this field. In contrast, postgraduate students studying health management do not receive specialised training in AMR⁵⁴.

It is important to note that AMR training may vary by region and educational institution. Furthermore, it's crucial to recognize that the availability and content of AMR training can vary depending on the region and educational institution. For instance, in Catalonia, AMR training has been developed by a network, catering to doctors, nurses, pharmacists, and other healthcare professionals. This program aims to provide these professions with a foundational understanding of AMR⁸⁶.

In contrast, in the region of Andalusia, several courses from the PIRASOA program focus on the prevention and control of healthcare-associated infections and Antimicrobial Stewardship Programs in hospitals and primary care. These courses are accessible to all healthcare professions.

Portugal

Several scattered initiatives have been described in the literature to improve physicians' continuous education, all of which are optional and voluntary. Portuguese medical specialty

associations and universities have their own courses on antimicrobial agents which usually have a section dedicated to antimicrobial stewardship, although these are voluntary courses, with limited places^{80,81}. In hospitals and primary care, the Local Coordination Groups develop educational initiatives that include awareness campaigns and training for health professionals, but these initiatives are generally not mandatory. Other isolated approaches are described in the literature as part of academic or international projects.

An example of this was the eHealthResp project, which included a digital platform consisting of two online courses and a mobile application specifically targeted at primary care physicians and community pharmacists. It included several presentations on respiratory infections and algorithms for respiratory infection management to improve antimicrobial prescription.⁸⁷

5. CASE STUDY: THE SWEDISH EXAMPLE

Sweden has consistently reported some of the lowest rates of AMR within the European Union relating both to human and animal health⁸. Sweden currently exceeds the WHO target of 60% for first and second line antibiotic use with 75% of therapies prescribed coming from this category¹². Folkhalsomyndigheten, the Public Health Agency of Sweden, attributes its success in this field to early awareness and long-term interdisciplinary methods of working⁸⁸.

Antimicrobial resistance is often discussed as a new public health issue and one which has only received international attention in recent years⁸⁹, however in Sweden, AMR has been at the forefront of public health since 1995⁹⁰ when the working group Swedish strategic programme against antibiotic resistance (known as Strama) was formed to tackle AMR.

The current Swedish model of implementing AMR education encompasses all areas of society, not healthcare workers alone. Education on AMR takes a ‘whole society’ approach, including AMR education within secondary school education and targeted information for all relevant actors (healthcare, institutions, the public) through the Antibiotic Smart Sweden platform⁹¹. For healthcare workers, there is a strong focus on AMR education and online modules have been developed for completion by healthcare workers. Additionally, Sweden’s approach to AMR considers not only use of antimicrobials within stewardship but the full lifetime of the antibiotic, including manufacturing, disposal and waste management, which is reflected in their educational approaches¹²

Sweden has a history of investing in education as part of a strategic plan for the infrastructure necessary for AMR surveillance and identification. Since 1997⁹⁰, there have been open national ‘Strama’ days aimed at providing education and networking on AMR, independent from the pharmaceutical industry. Collaboration on education delivery has been a strong focus of the Swedish system for combating AMR, with involvement of the Minister for Higher Education and Research in the AMR national action plan development, and AMR institutions report.

The approach in Sweden is regional, with specific agencies implementing at regional level and reporting to national. Within each region, officers for communicable disease control are employed and multidisciplinary Strama groups work to assist with AMR implementation. Regionally, AMR supportive structures have reported that they consider it important that AMR education is undertaken in clinical areas with education and support from clinical specialists.

In addition to developing its own educational system for AMR, Sweden has focused on a global approach to this issue⁹² and has commenced efforts to make education for healthcare workers more available internationally. In 2018, ReAct in collaboration with Uppsala university, launched its rebranded course *Antibiotic resistance - the Silent Tsunami* aimed at healthcare workers. The open access ReAct toolbox⁹⁰ offers links to available AMR resources globally. In 2023, a further course was translated and made available in English in a collaboration between Strama, ReAct,

the Public Health Agency of Sweden and Antibiotic Smart Sweden, aimed at providing information on structuring AMR programmes based on the Swedish example. Sweden has developed its role as an international influencer in AMR through education, networking, research and policy⁹³.

6. CONCLUSION

Antimicrobial resistance is a key threat to human health globally, including across the European region. Efforts to prevent the emergence of AMR require strategic multi-faceted responses that consider One Health approaches. If not addressed, it will have an extensive impact on healthcare systems and the economy. Education is an important component in building the understanding of healthcare workers in their practices and how they impact on the development of AMR. The current situation of education within the discussed countries is not yet standardised and requires concerted effort if gains are to be made in antimicrobial stewardship.

AMR in undergraduate education lacks a specific standardisation and is often absent. Undergraduate education is a core component of healthcare workers' practice and, if invested in, can contribute significantly to reductions in AMR. Strengthening postgraduate education will allow specialists in this field to emerge and develop an expertise within the chosen countries, an important step in preventing AMR. This can be complemented by CPD on AMR, which can build and support healthcare workers' knowledge and practices.

Overall, investment in AMR education at all levels is essential and can be achieved through strengthening national structures to support implementation of educational components of the AMR action plans. Tailored education at all levels that suits the background of healthcare workers can support understanding across healthcare workers in varying groups. Sharing experiences amongst countries can support the exchange of information and expertise, allowing countries across the EU to develop together.

Ultimately through these steps and a greater awareness of the need to support in this area, AMR education can be strengthened across Europe and in turn globally.

7. RECOMMENDATIONS

Based on the current available evidence, there are clear areas which can be developed within and amongst the target countries. Overall, it is clear that there is a need to take a strategic approach to AMR education at a national level to develop consistent results and institutionalize evidence-based practices which contribute to AMS within the healthcare workforce and system. In order to achieve this it is important that the target countries:

Ensure mobilisation of national structures to support planning for AMR education at a national level

To address AMR systematically, it is important that AMR education is conducted at a national level. A number of target countries currently have educational initiatives that are targeted at a regional level but fail to have a national reach. In order to strengthen the national approach to AMR it is important that educational initiatives take place across the entirety of the healthcare system¹¹. National structures are best placed to support such educational reform, including national bodies involved in: workforce development, curriculum planning, education and health system strengthening and others as relevant. This can be conducted in line with the EU's A European One Health Action Plan against Antimicrobial Resistance (AMR)⁷.

Realise actions outlined within national action plans for AMR through strategic planning for implementation of AMR education improvements.

Currently, national action plans for AMR in the target countries include actions for improving education and awareness of AMR amongst healthcare professionals. However, given the scale of this task it is reasonable to suggest that national structures responsible for AMR, in collaboration with the aforementioned relevant national structures, develop systematic implementation planning for these activities. It is recommended that existing tools for AMR NAP implementation be utilised as outlined in the WHO implementation handbook for national action plans on antimicrobial resistance: Guidance for the human health sector and following the 6 steps for sustainable implementation of national action plans on antimicrobial resistance¹¹.

Ensure healthcare worker education on AMR includes One Health approaches

As shown in the findings, there is a limited amount of education on a One Health approach across the target countries and this is evident within the previously presented survey results of healthcare workers' knowledge²⁹. One Health approaches are acknowledged to be a successful method of addressing AMR by considering all areas of AMR development⁵. In order for a One Health approach to be successful all partners must understand this concept. By integrating One

Health approaches into healthcare worker education, a more unified approach to AMS can be achieved.

Develop educational curricula which are tailored to specific health professionals role, educational level and need

It is acknowledged that healthcare workers from different professions have a role to play in the development or prevention of AMR. Considering the varied roles and responsibilities of healthcare workers, and the variance in educational level, it is important that education for AMR is available to all healthcare professionals in a format tailored to their understanding. As highlighted in the findings, there is limited education available for the broader healthcare professions. If AMR is to be successfully contained, it is imperative that all healthcare professionals be considered within strategic education developments.

Consider shared learning opportunities between and amongst countries within the EU to strengthen education provision and ensure a Leave No One Behind approach³

The enormity of the challenges facing the target countries in implementing AMR education is clear. AMR is a cross border issue which transcends national boundaries. As a number of European countries face similar challenges or have found successful methods to implement these components, (such as in the Swedish example), it is logical for countries to work together and to engage in information sharing. The EU has suggested that it could be seen as a best practice example for other countries and regions, suggesting collaboration amongst Member States could lead to success in AMS. In order for this to be actualised, all countries of the EU must make significant gains in this area. This could include standardised systems of education certification. By supporting the target countries, other EU Member States can improve AMS across the region and globally.

8. FUTURE AREAS FOR RESEARCH

This report has noted areas where there was a lack of research available which may have influenced the reliability of the report results. Therefore, the following areas for future research are recommended:

1. Research into the knowledge, attitudes, and perceptions of health educators within educational institutions of the target countries on AMR and One Health approaches.
2. Broader research on the educational knowledge on AMR of the healthcare workforce including: healthcare managers, doctors, pharmacists, nurses, auxiliary nurses, physiotherapists, dentists, occupational therapists, etc.
3. Further investigation of the availability of AMR education for healthcare delivery in specific settings beyond the hospital setting, like long-term care facilities, nursing homes, prisons, and primary care centres.
4. Further research on the feasibility of long-term sustainable and effective continuous education in the different health settings and its impact on antimicrobial prescribing, AMR, and clinical outcomes.

9. ANNEX 1.

Annex 1. *Competencies recommended for healthcare worker education on AMR by the WHO*¹⁶

Foundations that build awareness of antimicrobial resistance	<p>Knowledge: 1. Understand the development and main causes of AMR. 2. Understand the basic principles of infection prevention and control, i.e. hand hygiene to prevent transmission of infections. 3. Understand the impact of resistance on choice of antimicrobial therapy for treating infections. 4. Understand the morbidity, mortality and economic threat of AMR to human health. 5. Know the importance of optimising use of antimicrobials in the human and animal sectors to prevent development of resistance. Skills: 1. Ability to interpret and communicate the use of appropriate policy guidelines on AMR. Attitudes: 1. Promote awareness of AMR and appropriate antimicrobial use amongst all health care workers, patient communities and the general public. 2. Act to protect the effectiveness of antimicrobials as an ethical imperative and a public good.</p>
Appropriate use of antimicrobial agents	<p>Knowledge: 1. Understand that antimicrobials have different resistance potential (AWaRE categories). 2. Understand the specific roles of other health care workers. 3. Understand the consequences (intended and unintended) of the use of antimicrobial therapy in humans. Skills: 1. Ensure effective management of antimicrobials (according to scope of practice) in infection therapy. Attitudes: 1. Encourage patient and peer professional interactions on antimicrobial prescription and therapy. 2. Ensure timely and appropriate feedback to prescribers and other care groups. 3. Willingness to participate in quality improvement programmes for antimicrobial use. 4. Willingness to communicate the risk of development and transmission of AMR spread within and outside of multidisciplinary antimicrobial teams.</p>
Infection prevention and control (IPC)	<p>Knowledge: 1. Understands the infection chain especially the four components required for transmission of an infection: (organism, source, route of transmission and susceptible host). 2. Understand the role of hand hygiene to prevent transmission of pathogens. 3. Understand the principles of prevention of health care associated infections (HAI), including surgical site infections, catheter-associated bloodstream and urinary tract infections. 4. Importance of strategies to prevent infection at community and health facility levels, e.g. water, sanitation and hygiene (WASH), waste</p>

	<p>management and immunization. 5. Introduction to infectious diseases and role of the laboratory in identification of microbes and susceptibility testing to antimicrobials. Skills: 1. Practise hand hygiene at the right moment and with appropriate technique, according to WHO recommendations. 2. Contribute to the design and implementation of procedures for crisis management in infection control: alert management, patient identification, recall of potentially contaminated equipment and supplies, reporting and exchange with relevant health care professionals. 3. Implement and practise universal precautions and transmission based precautions in healthcare. Attitudes: 1. Advocate and demonstrate action and accountability for the implementation of IPC and hygiene and sanitation best practices in health care facilities and community settings respectively. 2. Advocate for WASH and for scaling up vaccines against common infections caused by microorganisms such as pneumococcus, rotavirus and Haemophilus influenzae type b. 3. Understand how and when to contact the infection control professional for their facility or area. 4. Promote proper health care waste management. 5. Promote injection safety awareness and techniques.</p>
Diagnostic stewardship and surveillance	<p>Knowledge: 1. Understand the role of national medicine regulatory authorities in the regulation of medicines: laws and regulations, registration, manufacturing, licensing, inspection and enforcement, pharmacovigilance, post-market surveillance, quality control, clinical trials, drug information. 2. Understand the importance of reporting suspected poor quality products, therapeutic ineffectiveness, and adverse events as they may generate signals on the compromised quality of the antimicrobial products. 3. Understand the importance of proper record keeping and use of drug codes (according to settings) for traceability of medicines. 4. Understand importance of AMR surveillance for characterization of resistance trends and measuring impact and burden of AMR to guide policy-makers in developing treatment recommendations. Skills: 1. Act as first line of surveillance to accurately identify and report suspicious, ineffective, and substandard antimicrobials to the appropriate authorities. Attitudes: 1. Respect and protect the privacy and identity of individuals in supporting or carrying out surveillance activities for AMR control.</p>

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