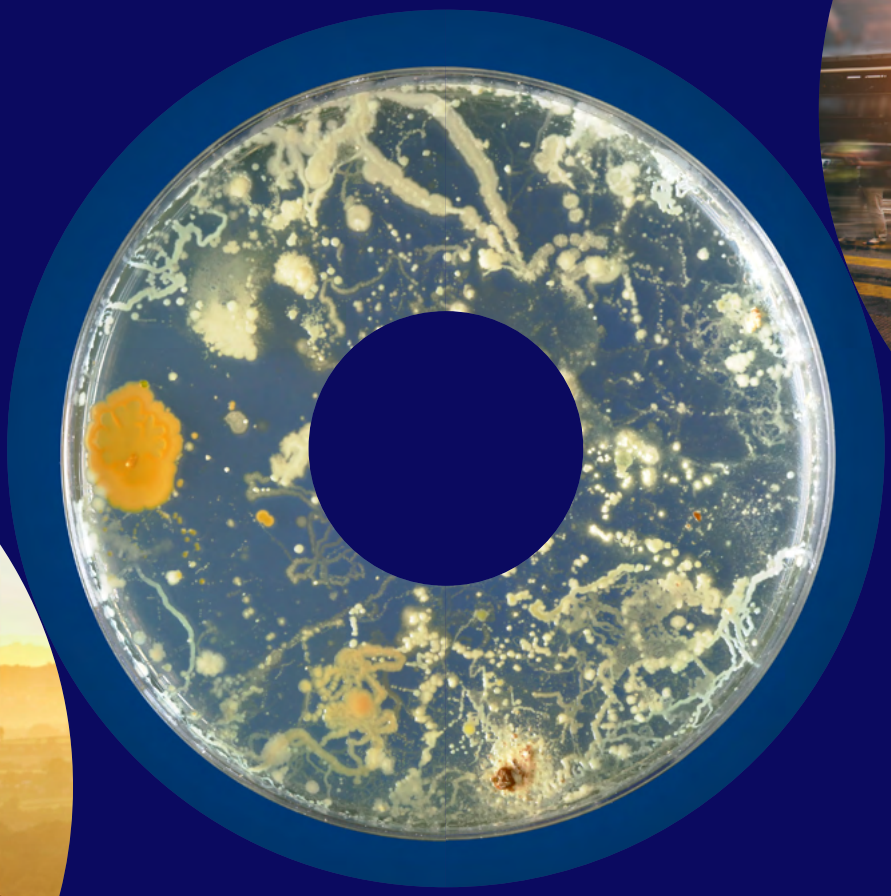
Strategic Research and Innovation Agenda

European Partnership on One Health Antimicrobial Resistance



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Page 40. *Boat on the Yamuna river.* Despositphotos, picture id 86905392.

Contents

Executive summary

Antimicrobial resistance (AMR) is a global health challenge that affects human and animal health, food security and the environment. The World Health Organization (WHO) has recognised AMR to be one of the top 10 global public health threats facing humanity[1]. The European Commission (EC) has also identified AMR as one of the top three priority health threats[2]. Immediate action is needed to boost AMR research and innovation (R&I) to better understand the biological mechanisms of resistance and evolution in microorganisms, as well as transmission routes and drivers, including social human factors. R&I is also needed to develop new treatments and rapid and affordable diagnostics, improve current treatment solutions, improve surveillance methods and design innovative interventions to prevent and mitigate AMR.

The European partnership on One Health AMR (the EUP OHAMR) is one of the key partnerships that has been identified by the EC within the framework of the Horizon Europe programme[3] to support R&I to respond to the challenges of AMR. By deploying a joint research programme, co-funded by the EUP OHAMR partners and the EC, the EUP OHAMR will contribute to the objectives of the European Union (EU) One Health Action Plan against Antimicrobial Resistance[4], to the European Parliament resolution on EU action to combat antimicrobial resistance[5] and to the Council Recommendation on Stepping up EU actions to combat antimicrobial resistance in a One Health approach[6]. The EUP OHAMR aims to align and coordinate strategic AMR R&I policies by attracting partners from EU and beyond, providing joint support to R&I and mobilising knowledge in the fight against AMR. It will deploy an integrated One Health approach, recognising that human, animal and plant health are interdependent and interlinked with the environment. The EUP OHAMR builds on the work of the Joint Programming Initiative on AMR (JPIAMR), but has a bigger ambition, as well as a stronger integration of social sciences and humanities, support of innovation, and international engagement to address the challenges of AMR. Through this approach, the EUP OHAMR will contribute to reduce the existing fragmentation of the R&I landscape, thus enabling the different One Health sectors and scientific disciplines to tackle the complex challenge of AMR with joint forces. The EUP OHAMR will engage with different national and international stakeholders to seek synergy and avoid duplication of efforts.

[1] WHO (2019): Ten threats to global health in 2019

[2] Health Emergency Preparedness and Response Authority (2022): HERA factsheet- HEALTH UNION: Identifying top 3 priority health threats

[3] Horizon Europe Work Programme 2023-2024, Health

[4] EU One Health Action Plan against AMR (2017)

[5] Resolution on EU action to combat antimicrobial resistance (1 June 2023)

[6] Recommendation on stepping up EU actions to combat antimicrobial resistance in a One Health approach (13 June 2023)

The European Partnership on One Health Antimicrobial Resistance (EUP OHAMR) will contribute to the objectives of the EU Action Plan on antimicrobial resistance (AMR), to combat the critical societal challenge of AMR and reduce the burden of AMR by:

- Enhancing European and global synergy, collaboration between the different One Health sectors and multiple disciplines, and alignment of strategic OH AMR R&I and policies to break silos;
- Boosting AMR R&I to generate knowledge and develop solutions to prevent and tackle AMR;
- Facilitating knowledge valorisation of R&I into products, policy and practice.

The EUP OHAMR is structured around three focus areas which will encompass: (i) prevent the emergence and spread of AMR, (ii) strengthen appropriate use of antimicrobials and infection prevention and control and (iii) provide innovative and cost-effective treatment options. Each of the three focus areas covers various aspects of AMR related to therapeutics, diagnostics, surveillance, transmission& evolution, and interventions.

To ensure its mission, the EUP OHAMR will deploy a wide range of activities organised under four programmes: (i) the R&I Funding programme, to provide a financial support to AMR R&I; (ii) the Capacity Strengthening Programme, to support training, networking and collaboration across disciplines, One Health sectors, professional domains (academia, industry including small and medium enterprises, SMEs), countries and career stages; (iii) the Data Exploitation Programme, to facilitate and promote access, sharing and (re) use of data and research infrastructures; and (iii) the Impact Programme for knowledge mobilization, to facilitate uptake of research results into products, practice and policy for maximum societal impact.

The current Strategic Research and Innovation Agenda (SRIA) presents the vision, mission, objectives, scientific focus, and implementation plan of the EUP OHAMR, and serves as the strategic foundation of the partnership to guide its future actions. The EUP OHAMR SRIA is the outcome of the efforts of the scientific community, member countries as well a broad range of stakeholders who contributed through numerous consultations organised by the Coordination and Support Action (CSA) DESIGN OH AMR[7], funded by the EC. This SRIA has been drafted in close collaboration with the WHO and the quadripartite organisations[8] to ensure an alignment with their respective AMR agendas[9,10]. An update of the SRIA is expected three years after the launch the partnership.

[7] European Commission: DESIGNing the European Partnership on One Health AMR

[8] The Quadripartite organisations: the Food and Agriculture Organization of the United Nations (FAO), the United Nations Environment Programme (UNEP), the World Health Organization (WHO) and the World Organisation for Animal Health (WOAH)

[9] WHO Global research agenda for antimicrobial resistance in human health (2023)

[10] Quadripartite A one health priority research agenda for antimicrobial resistance (2023)

Antimicrobial Resistance: one of the top 10 threats for human health

Alexander Fleming published his first article describing the effect of penicillin in 1929 in the British Journal of Experimental Pathology. Since then, many other antimicrobials including, antibiotics, antifungal, antiviral and antiparasitic agents have been developed. Antimicrobials have saved millions of lives, including previously common deaths associated with childbirth, routine surgeries and minor wounds. Modern medicine is reliant on antimicrobials to prevent infections that can occur in immunosuppressed patients undergoing organ transplant or cancer treatment.

"With doses too small, the microbes will not be killed, and there is a danger that they will be educated to resist penicillin. There are few simple rules for penicillin treatment:

- **First, use it only on a suitable microbe**
- **Second, use it in such a way that it gets into contact with the microbe.**
- **Third, use it in sufficient dose**
- **Fourth, keep the treatment long enough to kill them all"**

Sir Alexander Fleming, BBC recording for Science Notebook, 28 August, 1945

Unfortunately, as predicted early on by Alexander Fleming, microorganisms have the capacity to adapt and develop resistance to antimicrobials through genetic modifications (gene mutations or gene transfer). The extensive (and often improper) use of antimicrobials (in medicine, but also in agriculture to prevent infectious diseases in livestock, crops and horticulture) contributes to increasing selection of resistant microorganisms to alarming levels. Modern medicine is now running out of therapeutic options, and there is a huge risk to revert to the pre-antimicrobial era where even small wounds and routine surgery can be lethal. In addition, reduced antimicrobial efficiency may result in a decline of food production[11], contributing to hunger progression in poor countries.

[11] World Bank (2017); Drug-Resistant Infections: A Threat to Our Economic Future

Antimicrobial Resistance (AMR) occurs when bacteria, viruses, fungi and parasites change over time and no longer respond to antimicrobial medicines (such as antibiotics), making infections harder to treat and increasing the risk of disease spread, severe illness and death.

Several studies have attempted to investigate the impact of antimicrobial resistance (AMR) by examining its effect on health and the cost of AMR to society[12,13,14]. Murray et al,[13] estimated that 1,27 million deaths were attributable worldwide to infections caused by bacterial AMR in 2019[15]. The burden of bacterial AMR is unequal and disproportionally high in Sub-Saharan Africa and South Asia. The burden is also alarmingly high in Europe (in particular in Eastern and Central Europe). The burden of resistant bacterial infections in the European Union and the European Economic Area (EU/EEA) is comparable to that of influenza, tuberculosis and HIV/AIDS combined[13]. The O'Neill[12] report argued that bacterial AMR could kill 10 million people per year by 2050 without any prevention and mitigation measures.

The impact of antifungal, antiparasitic, and antiviral resistance on human health is for the moment more difficult to quantify than antibacterial resistance (with the exception of some well characterised pathogens such as HIV and the different species of Plasmodium responsible for malaria). This is mainly due to the lack of robust surveillance data worldwide, and to the absence of suitable diagnostic tests which reliably identify the aetiology of an infection. However, fungal drug resistance is already perceived to be a major threat to public health[16]. The number of deaths attributable to fungal infections nearly doubled, passing from 2 to 3.8 million deaths in eleven years[17], with antifungal resistance as one of the possible drivers responsible for this drastic increase. There is also growing evidence for an increasing rate in antiparasitic and antiviral resistance suggesting that these issues may be of major concern for public health in the coming years, directly affecting human health, or indirectly, through their impact on the livestock production.

The World Bank and the Organisation for Economic Cooperation and Development (OECD) have reported that from 2015 to 2050 the costs of AMR will be 3.5 billion USD per year for the expenditure on healthcare alone.[18] According to the World Bank[19], the economic impact of drug resistance could be as high as a 3.8% loss of global gross domestic product worldwide, including a 7.5% decrease in livestock output. In June 2017, OECD published estimates and calculations for the effectiveness and the cost-effectiveness of policies to promote effective use of antimicrobials and to prevent the spread of infections. For instance, the improvement of hand hygiene strategies could reduce the number of hospital days by 2.45 million and number of deaths by 43%, with an estimated total saving of 2.97 billion euro per year.

[12] O'Neill, J. (2014) Antimicrobial Resistance, Tackling a Crisis for the Health and Wealth of Nations.

[13] Murray C.J.L et al. (2022), Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis; DOI: 10.1016/S0140-6736(21)02724-0

[14] Cassini A.M.D (2018), Attributable deaths and disability-adjusted life-years caused by infections with antibiotic-resistant bacteria in the EU and the European Economic Area in 2015: a population-level modelling analysis; DOI: 10.1016/S1473-3099(18)30605-4

[15] Six pathogens (Escherichia coli, Staphylococcus aureus, Klebsiella pneumoniae, Streptococcus pneumoniae, Acinetobacter baumannii, and Pseudomonas aeruginosa) were responsible for more than 70% of the deaths attributable to infections caused by bacterial AMR.

[16] Kohlenberg A. (2022), Increasing number of cases and outbreaks caused by Candida auris in the EU/EEA, 2020 to 2021; DOI: 10.2807/1560-7917.ES.2022.27.46.2200846

[17] David W. Denning (2024) Global incidence and mortality of severe fungal disease; DOI: 10.1016/S1473-3099(23)00692-8

[18] OECD (2018); Stemming the Superbug Tide; doi: 10.1787/9789264307599

[19] World Bank (2017); Drug-Resistant Infections: A Threat to Our Economic Future

Climate change (mass flooding, temperature change), war (migration), pandemics, disinformation, urbanisation (increased contact between wild-life, humans and domestic animals) and increased exploration of the nature will also likely contribute to the spread of AMR in the coming years.

The burden of AMR on public health, thus, jeopardises achievement of several sustainable development goals (SGDs).

The World Health Organization (WHO) published its first Global Action Plan to combat AMR[20] in 2015. Since then, the severity of AMR has been acknowledged in the global health agenda by a number of high-level institutions including the UN Environment Assembly, the Council of the European Union[21,22,] the European Parliament[23], the European Commission[24], the G7[25], the G20[26], and the UN General Assembly[27]. In 2019, WHO declared AMR as one of the top 10 global public health threats facing humanity[28]. In 2022, the European Commission (EC) and the Member States, identified AMR as one of the top three priority health threats[29].

[20] World Health Organization (2015); Global Action Plan on Antimicrobial Resistance; ISBN: 9789241509763

[21] Council of the EU; Press release (17 June 2016)

[22] Council of the EU: Recommendation on stepping up EU actions to combat antimicrobial resistance in a One Health approach (13 June 2023)

[23] European Parliament: resolution on EU action to combat antimicrobial resistance (1 June 2023)

[24] European Commission, Action Plan adopted on 29 June 2017

[25] G7 health ministers; Communiqué (5-6 November 2017)

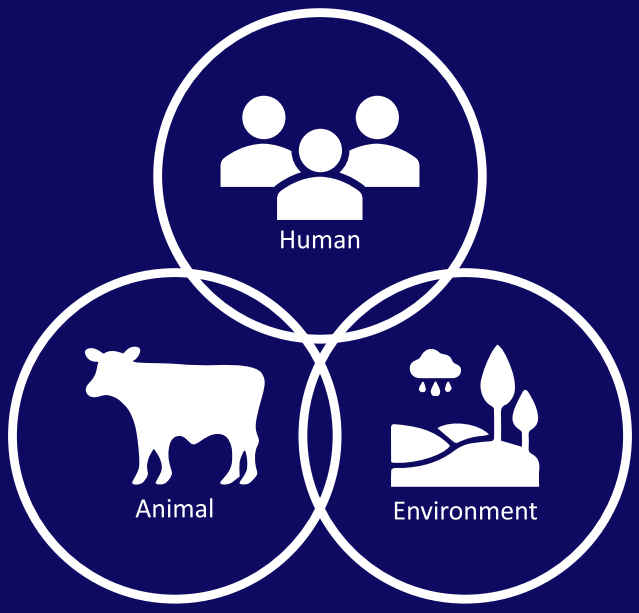
[26] G20 Health Ministers; Communiqué (19-20 May 2017)

[27] United Nations General Assembly, Member States, Communiqué (21 September 2016)

[28] WHO (2019): Ten threats to global health in 2019

[29] Health Emergency Preparedness and Response Authority (2022): HERA factsheet- HEALTH UNION: Identifying top 3 priority health threats

Considering that resistant microorganisms or resistance genes are transmitted between humans, animals (including wild-life and companion animals) and plants, often via the environment (via waste-water streams and soil[30]) and food, the different UN organisations recognised that a meaningful impact on human health could only be achieved through a One Health approach that requires a close collaboration between the different One Health sectors (human, animal and environment)[31,32]. The WHO joined forces with the Food and Agriculture Organisation of the United Nations (FAO), the World Organisation for Animal Health (WOAH) and the UN Environment Programme (UNEP) to form the UN Quadripartite and to develop a One Health Joint Plan of Action[33], in which AMR is one of the action tracks. In addition, in 2017, a UN Interagency Coordination Group on Antimicrobial Resistance (IACG)[34] was set-up to coordinate the work of the different UN agencies and the efforts of different One Health sectors including animal health, agriculture and environment to curb AMR.



One Health is an integrated, unifying approach that aims to sustainably balance and optimise the health of people, animals, and ecosystems. It recognises the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and interdependent.

Thus, there is an urgent need for a truly inter-sectoral, interdisciplinary and coordinated global approach to generate increased knowledge and solutions to prevent and tackle AMR.

[30] UNEP (2022) Environmental Dimensions of Antimicrobial Resistance

[31] United Nations General Assembly, Member States, Resolution A/RES/71/3, paragraph 15 of the Political Declaration

[32] Council Recommendation on stepping up EU actions to combat antimicrobial resistance in a One Health approach (2023)

[33] FAO, UNEP, WHO, and WOAH. 2022. One Health Joint Plan of Action (2022-2026). Working together for the health of humans, animals, plants and the environment. Rome.

[34] United Nations General Assembly, Member States, Resolution A/RES/71/3, paragraph 15 of the Political Declaration

[35] Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis, The Lancet

AMR is a major threat to human health around the world. Studies have estimated the global burden of AMR through its effect on incidence, deaths, hospital length of stay, and health-care costs for specific pathogen–drug combinations. The lancet report published in 2022 estimated that 4.95 million deaths were associated with bacterial AMR in 2019, with 1.27 million deaths directly attributable to bacterial AMR.[35]

Research and innovation: a pivotal instrument to prevent antimicrobial resistance and mitigate its effect

Existing tools to control and prevent AMR in human, animal and in the environment, and to treat infectious diseases are insufficient. More research and innovation (R&I) is needed to understand the mechanisms of resistance and evolution, as well as transmission routes and drivers, including social factors. R&I on development of innovative solutions for new treatments, revisited treatment regimens, rapid and affordable diagnostics, surveillance methods and preventive and mitigating interventions are also necessary. Boosting R&I will provide more understanding on AMR spread, and will allow the development of innovative social and technological solutions to decrease the burden of AMR.

Research and innovation to prevent and mitigate AMR is structured under five thematic areas (figure 1):

- Diagnostics
- Therapeutics
- Interventions
- Transmission and Evolution
- Surveillance

The five thematic areas are complementary but not mutually exclusive meaning that some topics are overlapping between different thematic areas. The five thematic areas are covering the One Health dimensions of AMR, as well as four cross-cutting themes: the role of socio-economic factors in the emergence and spread of AMR, the importance to translate research results into innovation, the role of implementation science to facilitate the translation and uptake of innovative solutions in real word settings, and the global challenges posed by AMR (figure 1).

The plurality of social science disciplines can offer an understanding of AMR, not only as a biological phenomenon but also how it is affected by social issues, such as behaviour, law, culture, ethics, and management science. Social sciences are positioned to respond to AMR as a problem that manifests in different ways in different places, reflecting the economic, social, behavioural and environmental contexts and challenges of different countries with diverse socio-economic settings. It is, therefore, crucial to include the perspectives of social sciences, alongside the life sciences, at all stages of the R&I planning and implementation. Similarly, intervention research and implementation science form part of a continuum, which seeks to improve the uptake of R&I in various forms.

While research is urgently needed to provide new solutions to curb AMR, the translation from research to innovation remains particularly challenging. In addition to the classical barriers to innovation, AMR research landscape faces additional challenges when it comes to innovation, such as the low return on investment in developing antimicrobials. Innovation is critical in the field of therapeutics, diagnostics and surveillance as well as for intervention and prevention of AMR, where, e.g. the creation of new technologies could be utilised to decrease drug resistance in AMR hotspots.

Efforts to mitigate AMR needs to be coordinated across countries and regions, both in high-income countries (HICs) as well as in low- and middle-income countries (LMICs). The latter are particularly vulnerable to the threat of AMR. Hence, the local contexts (prevalence of resistance genes, different infrastructures, laws, cultures, climates, societal frameworks, health systems, access to care, and resources) should be considered while developing new interventions, new treatments or new diagnostics.

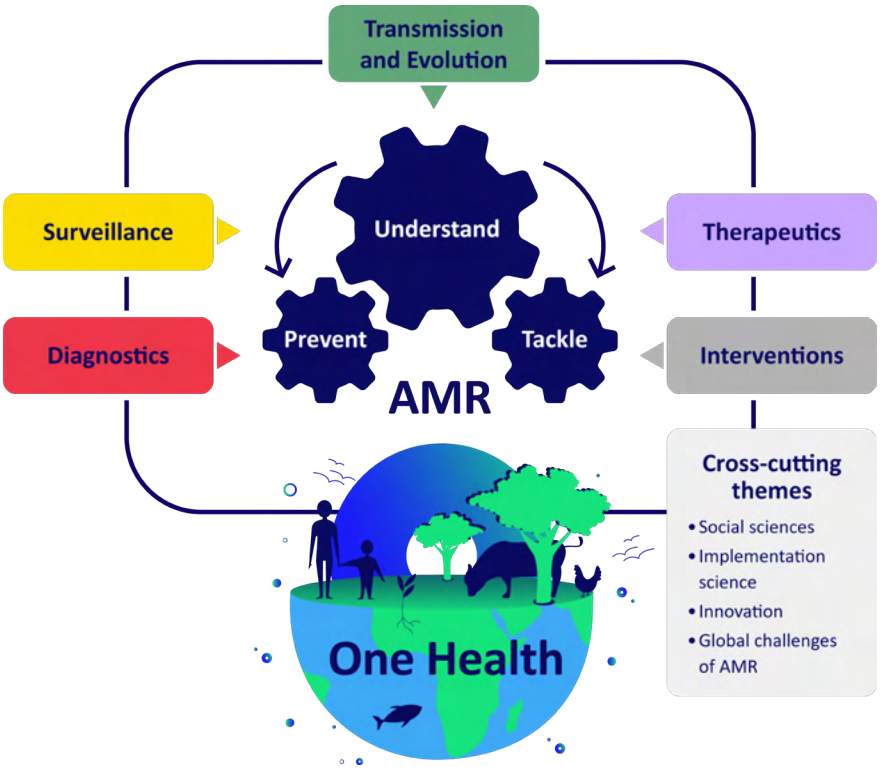


Figure 1. *The thematic areas and cross-cutting themes.*

Extensive work has been conducted to identify the R&I prospects under these five thematic areas The following section provides a concise description of the thematic areas (a detailed information on each of these thematic areas is provided in the long version of the Research and Innovation Objectives available on the EUP OHAMR webpage[36]).

[36] Research and Innovation Objectives of the EUP OHAMR

Diagnostics

Research and Innovation actions in the diagnostics area aim to develop and improve diagnostics to support the use of antimicrobials and alternatives to antimicrobials.[36]

Relevance of the Diagnostics area for the prevention and mitigation of AMR

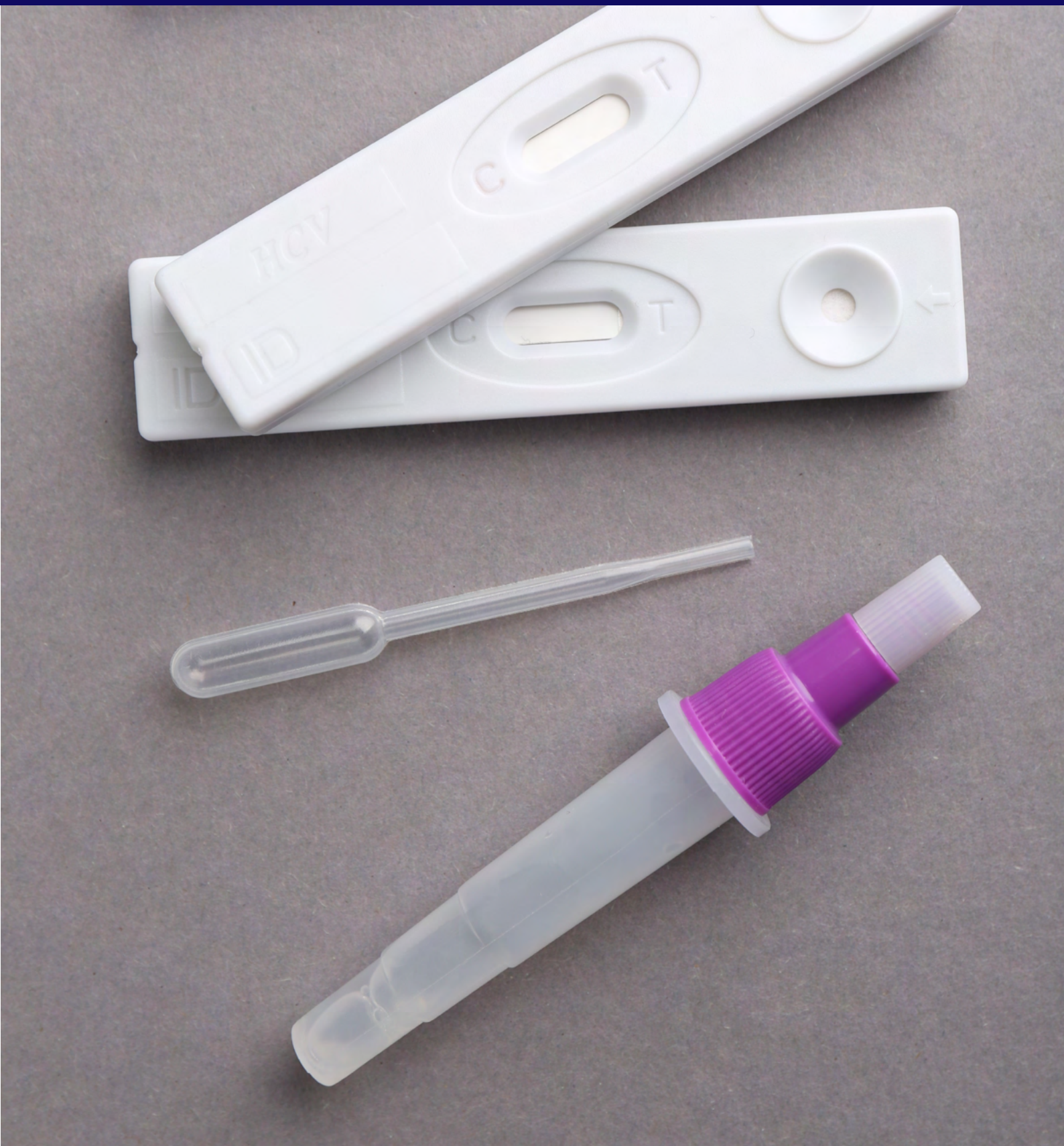
Diagnostics are tools that aim to detect and characterise microorganisms (species, strain, and their antimicrobial susceptibility) and that can be used to guide antimicrobial prescription to treat infection or to collect data for AMR surveillance. In the absence of proper diagnostics tests, empirical treatments are prescribed, leading to inappropriate use of antimicrobials (e.g. use of antibiotics for a viral infection), or to the prescription of less effective antimicrobials. When diagnostic tests are co-developed with novel antimicrobials, diagnostic tests can also facilitate the enrolment of patients during clinical trials. Tools developed for diagnostic purposes can in some cases also be used for detection of AMR in non-pathogenic microorganisms, and diagnostic data can feed into surveillance. Thus, development of new and improved diagnostics is vital.

Research and innovation prospects in diagnostics

R&I is needed to design and develop new rapid, cost-effective and reliable diagnostic tests and methods for identification and susceptibility testing of key pathogens, especially point of care diagnostics that can be performed on-site to guide antimicrobial prescription in both human, veterinary medicine and agriculture. Research should also develop environmental diagnostics, an emerging field, to assess the presence of resistant pathogens in the environment. R&I should also contribute to improve the performance, rapidity, feasibility and cost-effectiveness of the existing diagnostics. Since existing diagnostics are under-used by drug prescribers, research should identify and characterise the barriers preventing their acceptance and use. In addition, research in social and behavioural science should also propose solutions to overcome these barriers. Research should also show how diagnostic tests impact clinical outcomes, AMR spread and AMR management costs to convince local authorities to recommend the use of diagnostics. Development of appropriate diagnostic tools is also needed to support interventions to tackle AMR, including infection prevention and control, and antimicrobial stewardship.

[37] The Review on Antimicrobial Resistance: Tackling drug-resistant infections globally: final report and recommendations

Effective diagnostic testing plays a pivotal role in addressing AMR. Diagnostic tests are needed to identify the pathogen responsible for the infection and the drugs to which it is susceptible. The development and implementation of rapid point of care diagnostics for infectious diseases could reduce time-to-result, help select appropriate therapies, and assist in the prescription of narrow spectrum antibiotics.[37]



Therapeutics

Research and Innovation actions in the Therapeutics area aim to discover new therapeutic targets, develop new antimicrobial agents and therapeutic alternatives, and improve existing antimicrobials and treatment regimens.[36]

Relevance of the therapeutics area for the prevention and mitigation of AMR

The number of recently approved antibiotics is inadequate and fall short of what is required to mitigate the challenge of AMR. The progressive ineffectiveness of the current antimicrobials will inexorably lead to an immediate increase in the number of human deaths, while the possible banning of antimicrobials to treat animal and plant infections would likely lead to a decrease in food production, and increase hunger worldwide, unless new approaches are investigated and applied to treat infectious diseases. Hence, the development of new therapeutic solutions, including alternatives to antimicrobials, or the improvement of current ones is urgently needed.

Research and innovation prospects in Therapeutics

R&I is needed to improve current antimicrobial therapies and enhance the discovery, preclinical and early clinical development of novel antimicrobials, alternatives to antimicrobials and treatment strategies. This includes the repurposing of existing drugs as well as the optimisation of drug delivery and treatment protocols (dose, administration frequency, duration and drug combination). In addition, R&I in this thematic area should propose solutions to accelerate the entry of novel drugs and innovative treatment protocols to the market by developing pre-clinical models, by proposing innovative regulatory procedures, by developing alternative socio-economic models to stimulate drug development, drug production and drug supply while ensuring a high level of acceptability to end-users, appropriate use through antimicrobial stewardship and minimal impact on the environment. Research should also assess the risk of cross-resistance to antimicrobials used in different One Health sectors to aid development of evidence-based policies and guidelines aimed at rationalising the use of antimicrobials in animals and agriculture.

Interventions for prevention and mitigation

Research and innovation actions in the intervention area aim to develop innovative approaches to prevent and mitigate the emergence and spread of AMR, across One Health.[36]

Relevance of the intervention area for the prevention and mitigation of AMR

AMR poses a serious threat to human health in absence of rapid actions. Hence interventions based on new and existing evidences are needed to control and, if possible, reverse the progression of AMR. Those interventions could be to prevent and avoid the emergence and spread of AMR before it reaches a critical threshold, as well as to mitigate when AMR has already reached a significant level. Interventions would include a large variety of actions, such as the use of technological tools, the adoption of laws, regulation and protocols, the creation of economic incentives, or structural reorganisation. On one hand, the health authorities and the national ministries are responsible for the implementation of interventions while on the other hand the researchers are responsible for identifying the needs and opportunities for interventions, and for demonstrating the effectiveness of the interventions in the fight against AMR.

Research and innovation prospects in Interventions

R&I is needed to design, develop and improve approaches/tools, techniques and recommendations for responsible antimicrobial use, prevention and control of infections, surface decontamination, improved access to antimicrobials and quality diagnostics, development of newer vaccines, improved access to water, sanitation, and hygiene, antimicrobial recycling, better agricultural practices, and strengthening health systems. It would also entail identification of barriers during the uptake and scale up of the innovative approaches/tools as well as evaluation of their cost effectiveness. R&I should establish a sound rationale to design pilot interventions, as well as to prove their effectiveness through defining metrics and measures. The pilot interventions could be either technical or social. R&I is also needed to identify the barriers preventing the uptake of a proven intervention and its implementation and to develop strategies to overcome these barriers. The cost-effectiveness of an intervention as well as its acceptability and adaptability to different settings and countries/local contexts is crucial and needs to be well investigated.

Transmission and Evolution

Research and innovation actions in the Transmission and evolution area aim to understand and prevent the transmission and evolution of antimicrobial resistance in a One Health context.[36]

Relevance of the Transmission and evolution area for the prevention and mitigation of AMR

Rapid preventive actions need to be implemented to avert the threat of AMR. Such actions include, but are not limited to, the reduction of AMR selective factors in the environment, the restriction of unnecessary AMU, and the control of human or animal exposure to contaminated water. Those actions are difficult to accept by the targeted end-users without strong rationale, and strong evidence of effectiveness, as they often come with an associated cost. Understanding the mechanisms involved in the transmission and evolution of AMR will help health authorities to design efficient preventive interventions. In addition, identifying interventions with proven effects will encourage health authorities to adopt and scale-up the interventions. Furthermore, a better understanding of transmission and evolution mechanisms of AMR could help to identify new drug targets, or improve the existing drugs.

Research and innovation prospects on Transmission and Evolution

R&I is needed to improve the understanding of both the evolution and the physical transmission of microorganisms resistant to antimicrobials within and between humans, animals and the environment. This includes exploring mechanisms involved in gene mobilization, transfer of resistance, mutations, epigenetic modifications, physical transmission and maintenance of resistance under various conditions. It also includes understanding drivers of such processes, all the way from chemical and molecular drivers to socio-economic and behavioural ones (including climate change and population migration), and the design of models to estimate the risk of resistance transmission. Although the massive use of antimicrobials in the medical and agricultural sectors have been shown to be associated with increased AMR in the environment, it remains still unclear how, and to which extent, the prevalence of resistant genes in animals and in the environment contributes to AMR risk in humans. Research should also contribute to identify and characterise AMR reservoirs, evolutionary arenas and provide evidence behind the directionality and scale of AMR transmission (e.g. from environment/animal/food to humans, but also from non-pathogenic, such as environmental microbiota, to pathogenic strains).

[38] Dunne, K et al. (2017), Intercountry Transfer of Triazole-Resistant Aspergillus fumigatus on Plant bulbs, Clinical Infectious Diseases

Resistance to triazoles agents, the leading antifungal therapy in treating aspergillosis caused by Aspergillus fumigatus – a fungus that causes fatal pneumonia in immunocompromised patients, is a growing problem. The widespread use of triazole antifungal drugs as fungicides in agriculture and floriculture is considered to contribute to this type of resistance. Plant bulbs have been proposed to be a vehicle for international spread of the triazole-resistant Aspergillus fumigatus. Billions of bulbs are produced every year for a global market.[38]

Surveillance

Research and innovation actions in the Surveillance area aim to optimise surveillance systems and monitoring tools and methods to understand the drivers and burden of AMR in a One Health perspective and support decision making at all levels.[36]

Relevance of the Surveillance area for the prevention and mitigation of AMR

Surveillance of AMR involves continuous, systematic collection, analysis, interpretation and communication of data to monitor and act on the level of AMR and antimicrobial use and consumption (AMU/AMC). Surveillance is fundamental to estimate the burden of AMR, and to raise the public awareness on AMR risks. AMR surveillance will also guide the prescription of antimicrobials in humans, animals and crops when adequate diagnostic testing is missing. It acts as an early-warning signal to implement targeted interventions, provide data to better understand the transmission, directionality and risk of the spread of AMR, and produce evidence to evaluate the effect of an intervention. For those reasons, the improvement of the current surveillance strategies, including the optimisation, standardisation and harmonisation of the current surveillance system, is fundamental.

Research and innovation prospects in Surveillance

R&I is needed to strengthen the research on surveillance systems, methods, interpretative guidelines, and communication tools to optimise the surveillance of AMR and antimicrobial use and consumption (AMU/AMC), using a One Health approach. In particular, research should identify the samples and data to be collected for an effective surveillance and develop monitoring tools and methods, especially for environmental surveillance where data are lacking. Even where substantial surveillance data are already available, their heterogeneity, in terms of nature and quality and sustainability, constitute a real issue for optimising their use. Research should contribute to prioritise and/or harmonise the indicators (microbial species and AMR/ AMU data to collect), as well as the place and time to collect them. Research should define standardised and harmonised sampling, analysis, interpretation and communication protocols, to allow comparison of the data across different One Health sectors, including wildlife and the environment, and across different regions of the world. Surveillance data should be integrated and analysed together with other types of data, such as meta-data, epidemiological data or social data, for which informatic tools should be developed. Research should also propose strategies and tools to facilitate and encourage data collection, data storage, data sharing, dissemination, communication, and the involvement of the end-users from data collection to data use. Economic studies should demonstrate the cost-effectiveness of different strategies for surveillance, and propose strategies/ frameworks, for quality assured AMR surveillance both in LMICs and in high income countries. Economic or social barriers preventing the development of surveillance should be identified, and solutions should be proposed.

A European Partnership on One Health AMR to support AMR Research and Innovation

The European partnership on One Health AMR (EUP OHAMR) is one of the key European partnerships that has been identified by the EC within the framework of the Horizon Europe R&I programme[39] to respond to the challenges of AMR described in the earlier section. The EUP OHAMR will be launched in 2025 for a period of 10 years. The EUP OHAMR will enhance coordination and alignment of actions among EU countries and beyond, and boost investments to support R&I across different One Health sectors in the fight against AMR. The efforts of the EUP OHAMR are in alignment with the "Council Recommendation on Stepping up EU actions to combat antimicrobial resistance in a One Health approach"[40] and with the European Parliament recommendation on antimicrobial resistance[41], two recommendations underlying that support to research is crucial for the development, evaluation and implementation of measures against AMR. The EUP OHAMR will also contribute to achieve the objectives identified in the "EU One Health Action Plan against AMR"[42].

The specific objectives of the EUP OHAMR will be to:

- Enhance European and global synergy, collaboration between the different One Health sectors and multiple disciplines, and alignment of strategic OH AMR R&I and policies to break silos;
- Boost AMR R&I to generate knowledge and develop solutions to prevent and tackle AMR;
- Facilitate knowledge valorisation of R&I into products, policy and practice.

The EUP OHAMR builds on the experiences and well-established networks and processes of the Joint Programming Initiative on AMR (JPIAMR). However, the EUP OHAMR extends to a broader and more integrative programme to further strengthen synergy and enable multi and inter-disciplinary research across the social and life sciences to contribute to the understanding of the biosocial dynamics of AMR through a holistic One Health approach. The EUP OHAMR will integrate implementation science to apply methods and interventions in real-world settings, including the study of methods to promote the adoption, uptake and integration of evidence-based practices and interventions for health impacts. The EUP OHAMR will also enable innovation through the recent progress made in computational science and Artificial Intelligence (AI) that will facilitate the real-time integration of surveillance and diagnostics data as well as tools that will assist the design of new therapeutic molecules. In addition, the EUP OHAMR has stronger elements of innovation and uptake of solutions

[39] Horizon Europe Work Programme 2023-2024, Health

[40] Recommendation on stepping up EU actions to combat antimicrobial resistance in a One Health approach (13 June 2023)

[41] EP resolution on Prudent use of antibiotics and more research needed to fight AMR (1 June 2023)

[42] EU One Health Action Plan against AMR (2017).

by industry, society and policy makers through reinforced engagement with stakeholders, as well as capacity strengthening and data facilitation. Furthermore, the EUP OHAMR aims to expand international networks and attract new partners from the EU and beyond.

The EUP OHAMR will reduce duplication of efforts by promoting coordination and alignment of national, EU and international AMR R&I policies and actions, and by increasing collaboration between human health, animal health and environment actors, as well as between different scientific disciplines. The EUP OHAMR will thus result in increased knowledge, solutions and evidence-base to understand, prevent and tackle AMR, thereby strengthening the European Research and Innovation Area (ERA) ecosystem and contribute to making the EU a best-practice region on AMR.

AMR is a complex problem which will need cooperation of multiple related and relevant research programmes. The EUP OHAMR will work in close collaboration and seek synergy with other European partnerships and international initiatives (see the section “Synergies and Collaborations with other Partnerships, initiatives and Stakeholders" for more details). In particular, the EUP OHAMR will be in close contact with the European Partnership on Animal Health and Welfare (EUP AH&W) to seek synergies, collaborate on joint activities and avoid overlaps in the areas of AMR and animal health. R&I on AMR in non-zoonotic, veterinary pathogens for food-producing animals will be covered by the EUP AH&W whereas, the EUP OHAMR will address transmission of AMR from animals to humans (and vice versa) as well as aspects of AMR in wildlife and companion animals. The OHMAR will also seek synergy and collaboration with other EU partnerships, such as Global Health European & Developing Countries Clinical Trials Partnership Joint Undertaking (GH EDCTP3-JU), Fostering European Research Area for Health Research (ERA4Health), and Pandemic Preparedness, that will cover clinical trials for infectious diseases. The EUP OHAMR will also collaborate closely with the second Joint Action on Antimicrobial Resistance (JAMRAI-2) to provide a scientific base for the implementation of guidelines and national action plans.

The present EUP OHAMR Strategic Research and Innovation Agenda (SRIA) serves as the strategic foundation of the partnership to guide its future actions and support the development of its annual work plans. The SRIA has been developed based on a large number of consultations (please consult Annex 1 for more details on the SRIA development process). This SRIA has been drafted in collaboration with the WHO and the quadripartite organisations[43] to ensure an alignment with their respective AMR agendas[44,45].

[43] The Quadripartite organisations: the Food and Agriculture Organization of the United Nations (FAO), the United Nations Environment Programme (UNEP), the World Health Organization (WHO) and the World Organisation for Animal Health (WOAH)

[44] WHO Global research agenda for antimicrobial resistance in human health (2023)

[45] Quadripartite A one health priority research agenda for antimicrobial resistance (2023)

[46] Hedman, H, et. al (2020), A Review of Antimicrobial Resistance in Poultry Farming within Low-Resource Settings, Animals

Food animal production is rapidly expanding as well as the use of antibiotics to improve meat production through increased feed conversion, growth rate promotion and disease prevention. The promotion of intensive poultry farming could address issues of food security, but it may also increase risks of AMR exposure to poultry, other domestic animals, wildlife, and human populations through the residues of the antibiotic residues in the food and in the environment.[46]

The EUP OHAMR: Vision, Mission, and Values

Vision

Reduce the burden of AMR

The vision of the EUP OHAMR is to improve the response to the threat of AMR by reducing the spread of AMR in humans, animals and the environment through an integrated One Health approach, and by increasing the number of effective treatment options available in the different One Health sectors.

Mission

To boost One Health research and innovation leading to improved surveillance of resistant pathogens, better diagnostics and effective treatment of infections and to prevention measures reducing the use of antimicrobials and spread of AMR

The EUP OHAMR will boost R&I to understand, prevent and tackle AMR by increasing and coordinating the investment in AMR R&I, by facilitating the use and re-use of available data, by reinforcing AMR R&I capacities and by facilitating the uptake of research results by industry, society, and policy makers. It will support translation and implementation of research results and innovation through increased interaction between regulators, scientists and end-users. Considering the existing fragmentation between the different One Health sectors, the EUP OHAMR will strengthen synergy and improve links within One Health R&I by better coordinating national activities and investment and by developing common objectives for participating countries based on a joint and agreed Strategic Research and Innovation Agenda. It will implement concrete actions for breaking silos, and boost One Health R&I to leverage the effort done in individual OH sectors.

Values

One Health

The “One Health approach” in the EUP OHAMR will focus on better understanding how the use of antimicrobials and the spread of resistant microorganisms and resistance determinants in and/or between humans, animals and the environment contribute to the emergence and spread of AMR in humans and to its health consequences, and which interventions are effective to control and mitigate the effects of AMR (figure 2).

Figure 2. *One Health focus of the EUP OHAMR.*

As highlighted in the introduction, microorganisms, and the resistant genes they carry, can move between humans, animals, plants and the external environment through food consumption, air, water or direct contact. Decreasing the tremendous impact of AMR on human health thus requires a better cooperation between actors in the different OH sectors. Despite that the necessity of interlinkage between the different One Health sectors is widely accepted by the AMR community, silos still exist and limit the exchange of information between different disciplines and groups. For this purpose, the EUP OHAMR will engage actively with a wide range of stakeholders, policy makers and other European Partnerships with a focus on animal health, agriculture and food security, water and waste management, and the environment. This will ensure that the impact of AMR in other OH sectors on human health is addressed through collaborative actions in order to reduce fragmentation and to avoid overlaps (see also the section on Synergy and Collaborations)[47].

The EUP OHAMR will also boost intersectoral and interdisciplinary research, for which funding opportunities are dramatically lacking by supporting technical and social interventions aimed at decreasing the release of antimicrobials to the environment from different sources. While the use of antimicrobials in the human health sector and in agriculture has a clear impact on the concentration of antimicrobials in the environment, the consequence of such pollution on AMR evolution and on the risks to human health are still unclear. By supporting the development of methods that will facilitate the integration of surveillance data on AMR, AMU and AMC collected in the different One Health settings and investigating the directionality of transmission in and between the One Health sectors, EUP OHAMR will guide AMU and preventive measures to be implemented by public health authorities, health care, farmers and industry.

[47] In particular, the EUP OHAMR will work in close contact of the Partnership on Animal Health and Welfare (EUP AH&W). Resistance affecting non-zoonotic, veterinary pathogens for food-producing animals is one of the focus this partnership and some of the animal health and welfare measures developed by the EUP AH&W may have a strong contribution to the EUP OHAMR overall goal.

Equality, Diversity, and Inclusion

Pathogens circulate on Earth without geographical borders and impact individuals irrespective of their gender, age or socio-economic settings, making AMR a global threat. However, infections and AMR affect different human populations differently. Treatment regimens adapted for children or neonates are lacking, reinforcing their risk to AMR. While, in LMICs, resistant infections are mainly driven by less access to second- or third-line antimicrobials and diagnostics, limited surveillance, lack of antimicrobial stewardship, lack of hygiene and proper sanitation, inadequate infection prevention measures, inadequate infrastructure for managing human and animal waste streams. In HICs, AMR is largely driven by high consumption of antimicrobials for medical use, and by an inequality of access to healthcare system (low-resource populations). Additionally, men and women are not exposed to AMR in a similar way and their adherence to treatment protocols differ. The present SRIA intends to cover the R&I priorities relevant for populations living in different socio-economic, demographic or geographical context. The SRIA preparation involved a wide range of stakeholders including experts from different backgrounds and geographic origins, as well as different end-users' networks such as EPHA[48] and PENTA[49] to reflect the challenges of AMR in the society, at large. The drafting of this SRIA has also been subjected to different consultations involving global representations to highlight the respective challenges (see the Annex 1 for more details).

R&I to be supported in the framework of the EUP OHAMR will adhere to the principles of social and gender equity, cultural sensitivity and economic viability while addressing the challenges of AMR as well at an organisational level including, the composition of the consortia, leadership and management of R&I projects. The EUP OHAMR will also promote the inclusion of social sciences and implementation science in its R&I efforts to ensure that economic, geographical, social, behavioural and environmental contexts will be considered at all stages of the R&I planning and implementation. R&I projects to be supported by the EUP OHAMR will undertake an intersectional and multi-dimensional approach by integrating sex, gender and other individual and population-level determinants of health (such as age, socio-economic status, ethnicity, religion, class, caste, and other factors) into the project's design, implementation, monitoring, evaluation and knowledge translation activities and plan context-specific interventions that are accessible and affordable to the community.

Knowledge Valorisation

Enhanced knowledge translation and uptake of research and innovations into solutions and evidence-based policy is one of the main objectives of the EUP OHAMR. Through the various programmes on transnational R&I calls, capacity strengthening, data exploitation and knowledge mobilisation, the EUP OHAMR will ensure that the knowledge generated from funded R&I projects are transformed into sustainable solutions available for uptake for broad societal use and maximal impact (see the section related to the "Impact Programme for knowledge mobilization" further

[48] European Public Health Alliance

[49] Paediatric European Network for Treatment of AIDS

details). This includes knowledge dissemination, which involves making R&I findings known, accessible and available for uptake for the benefit of the society as well as providing a framework for engagement of the knowledge generators with the knowledge-users. The EUP OHAMR will also facilitate skill development and cross-fertilisation of competences and strengthen capacity of researchers. The measures for knowledge dissemination, uptake and translation will be integrated throughout the overarching activities of the EUP OHAMR. This will help support the researchers/ innovators to receive a clear understanding of the societal and public health impact as well as market opportunity, and route to translation of innovation and evidence through collaboration between academia and industry. The approaches will be solution-oriented and transdisciplinary and involve implementation research, social and behavioural sciences covering the OH sectors. The EUP OHAMR will thus facilitate the dissemination, transfer, and uptake of the knowledge generated through valorisation.

Strengthening of the European Research Area (ERA)

The EUP OHAMR aims to strengthen Europe resilience to the emerging threat of AMR by developing solutions to improve the detection, prevention and treatment of infections caused by antimicrobial resistant pathogens, as recommended in the recent EU Council Recommendation to combat antimicrobial resistance in a OH approach. The EUP OHAMR will work hand in hand with the EU Member States and the different directorates of the EC and EU agencies to address the objectives of the EU AMR Action Plan by developing new tools against AMR, new treatment solutions and by providing scientific driven evidence to guide policy makers and improve current regulations. The EUP OHAMR will provide a better coordination and alignment of actions and research funding investments among EU countries and beyond. It will facilitate national coherence of AMR research programmes, across different One Health (i.e human health, agriculture, environment) sectors and professional domains (i.e academia and industry). The EUP OHAMR will leverage investments, avoiding unnecessary duplication of efforts and will thus provide support for scaling up R&I efforts in Europe. Activities to strengthen research capacity in under-represented countries (including widening countries) and in LMICs will be a central objective. By strengthening the capacity of the research community and increasing the mobility of researchers, the EUP OHAMR will support the sharing of best practices within Europe and beyond, especially towards widening countries[50] and countries that are highly affected by the burden of AMR. Support of early career scientists across all OH sectors, disciplines and boundaries will be prioritised in order to increase their expertise and facilitate their integration into the AMR scientific community. By creating a platform for knowledge valorisation, the EUP OHAMR also aims to identify and remove the barriers for innovation and to support the transfer of knowledge to policy makers, industry, SMEs, and end-users, reinforcing the long-term competitiveness of Europe.

[50] European Commission: Horizon Europe Widening – Who should apply?

Focus areas of the EUP OHAMR

A prioritisation exercise organised during the preparation of the EUP OHAMR resulted in the identification of three challenge-driven focus areas that should be addressed by the EUP OHAMR:

- Prevent the emergence and spread of AMR
- Strengthen appropriate use of antimicrobials and infection prevention and control
- Provide innovative and cost-effective treatment options

These three focus areas will guide the development of the annual joint transnational calls and activities. Each focus area includes topics and sub-topics from more than one thematic area (Transmission and Evolution, Therapeutics, Diagnostics, Surveillance, Interventions for prevention and mitigation, see figure 3). These topics and subtopics should be seen as examples and are not exhaustive. Each focus area covers different disciplines (i.e. biological sciences, chemistry, social sciences, engineering) and includes fundamental, translational and implementation research as well as innovation.

The section below presents the three focus areas briefly. More details on the research and innovation sub-topics included under the focus areas could be found in the Roadmap of actions[51]. An update of the EUP OHAMR SRIA is foreseen after the three first years of the partnership, leaving the possibility to add emerging focus area(s), if needed.

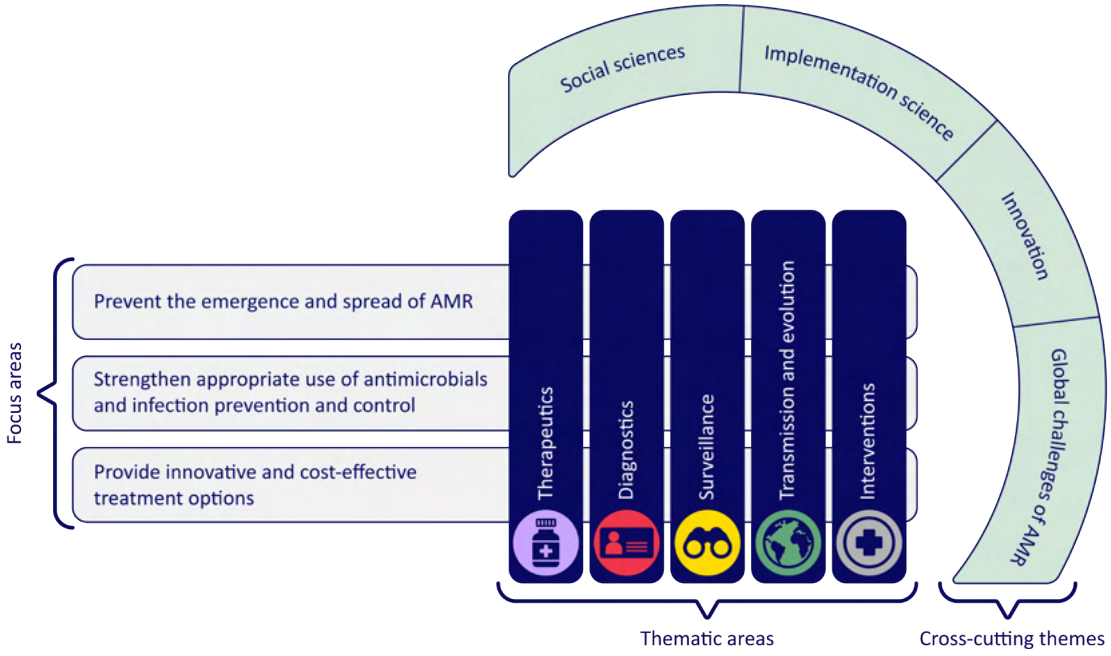


Figure 3. *Relationships between the thematic areas and the Focus Areas.*

[51] Roadmap of action (2025-2032) of the EUP OHAMR

Focus Area 1: Prevent emergence and spread of AMR

Challenge

Current measures to decrease and control the emergence and spread of AMR and recent technical advances are still insufficient to reduce the burden of AMR. In addition, it is still unclear how the recent measures taken in some One Health sectors, such as the reduction of antimicrobial use in animal husbandry or the restriction of some critical antimicrobials for human cure only, will have an impact on human health. In the coming years, novel and/or improved measures need to be developed to control AMR, based on a better understanding of the mechanisms driving the emergence, evolution, selection, persistence, and transmission of AMR, in and between different OH sectors.

Objectives

- Identification and characterisation of the factors (molecular, behavioural, ecological, social, societal, economic and environmental[52]) and mechanisms driving the emergence, evolution, selection and maintenance of the resistance genes and resistant microorganisms.
- Identification and characterisation of the risks, drivers, scale and direction of the AMR transmission routes within and between the different OH sectors, utilising mathematical modelling and approaches based on Artificial Intelligence (AI).
- Development of innovative solutions to limit the discharge, persistence, accumulation of antimicrobials and resistant genes/micro-organisms in the environment.[53]
- Comparison of existing interventions aiming to limit AMR emergence and spread, and evaluation of their impact on AMR, as well as their social, societal and economic benefit.
- Development of solutions to improve the access to social and technological innovations and interventions aiming to reduce AMR emergence and spread, and to facilitate their availability and their uptake by end-users.

[52] Factors responsible for an inappropriate Antimicrobial use (AMU) will be covered by the focus area 2: "Strengthen appropriate use of antimicrobials and infection prevention and control".

[53] A broad definition of environment is used throughout the document, including social and physical environment, in vivo environment (e.g. microbiota) and wildlife.

Inappropriate use and overuse of antibiotics are one of the main drivers of AMR and have a detrimental impact on the effectiveness of these critical medicines. Curbing the overuse and misuse of antimicrobials in humans, animals and plants is vital to reduce the number of drug-resistant infections.[54]

Focus area 2: Strengthen appropriate use of antimicrobials and infection prevention and control

Challenge

AMR is, to a large degree, driven by misuse and overuse of antimicrobials and poor infection prevention and control practices, in multiple OH sector including human health, animal health, aquaculture, agriculture and horticulture.

Objectives

- Identification and characterisation of the behavioural and social/societal factors leading to an appropriate or excessive use of antimicrobials.
- Design of social and technical innovations, including diagnostics and digital tools, aiming to facilitate the appropriate use of antimicrobials.
- Design of social and technical innovations aiming to prevent or reduce the incidence of infections.
- Comparison of existing interventions aiming to reduce antimicrobial use or prevent infectious diseases and evaluation of their impact on human health, as well as their social, societal and economic benefit.
- Identification of barriers to uptake of and access to social, societal and technological innovations aiming to improve antimicrobial use and prevention of infection, and development of solutions to overcome these barriers.

Focus area 3: Provide innovative and cost-effective treatment options

Challenge

Resistant drug infections are responsible for an increasing number of treatment failures, increased mortality and decreased food productivity.

Objectives

- To develop new antimicrobials, novel treatment protocols or alternative treatment therapies against Human Infectious diseases along with their respective diagnostics.
- To improve, preserve and reinforce the clinical efficacy of the current treatment antimicrobials.
- Identification of barriers to access, availability, quality and uptake of therapeutic solutions and development of solutions to overcome those barriers.
- Assessment and prediction of the impact of economic incentives and regulations on drug development, drug production, drug supply and treatment availability.

[54] Klein, E, et al. (2018) Global increase and geographic convergence in antibiotic consumption between 2000 and 2015, PNAS

Programmes and actions of the EUP OHAMR

The EUP OHAMR will implement different actions to fulfil its mission. These actions will be structured in four different programmes (figure 4):

- R&I Funding programme: to provide financial support to AMR R&I
- Capacity Strengthening Programme: to support training, networking and collaboration across disciplines, OH sectors, countries and career stages.
- Data Exploitation Programme: to facilitate and promote access, sharing and (re) use of data and research infrastructures
- Impact Programme for knowledge mobilisation: to facilitate uptake of research results into products, practice and policy for maximum societal impact

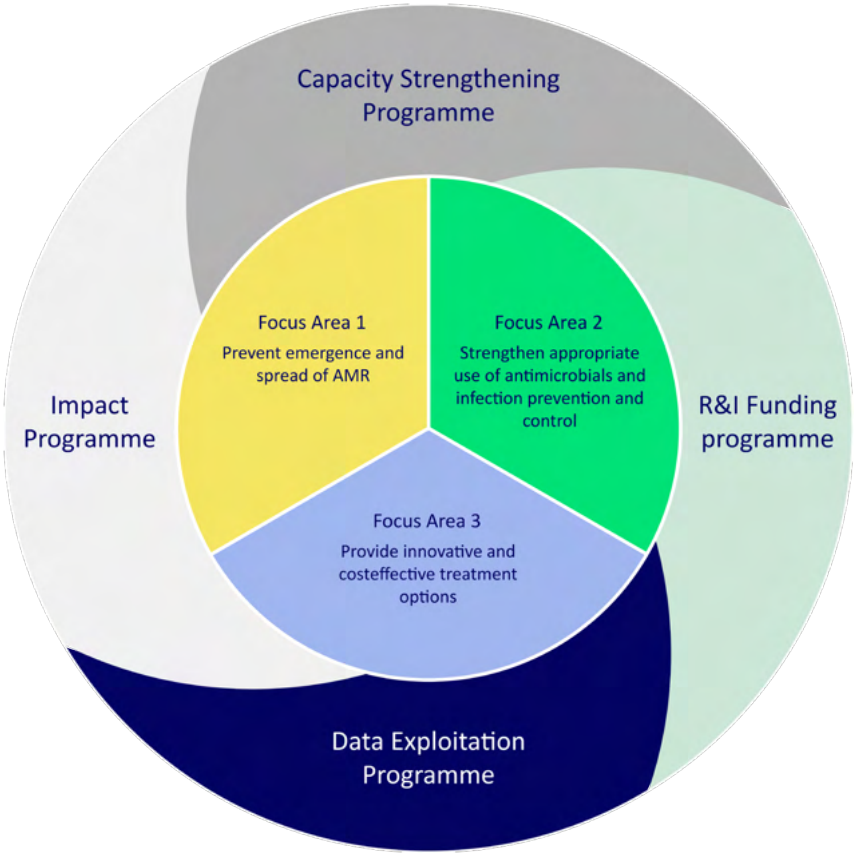


Figure 4. *The four programmes and the three focus areas will contribute to tackle the EUP OHAMR objectives.*

The execution of the calls and all measures to be included in calls will be handled by the R&I Funding programme, whereas the other programmes will be responsible to coordinate and organise additional activities and events (figure 5). The other programmes may also contribute to the drafting of the annual call based on the needs identified in the mapping exercises conducted by the respective programme. Training activities will be performed by the Capacity strengthening programme in collaboration and cooperation with the Impact programme and the Data exploitation programme.

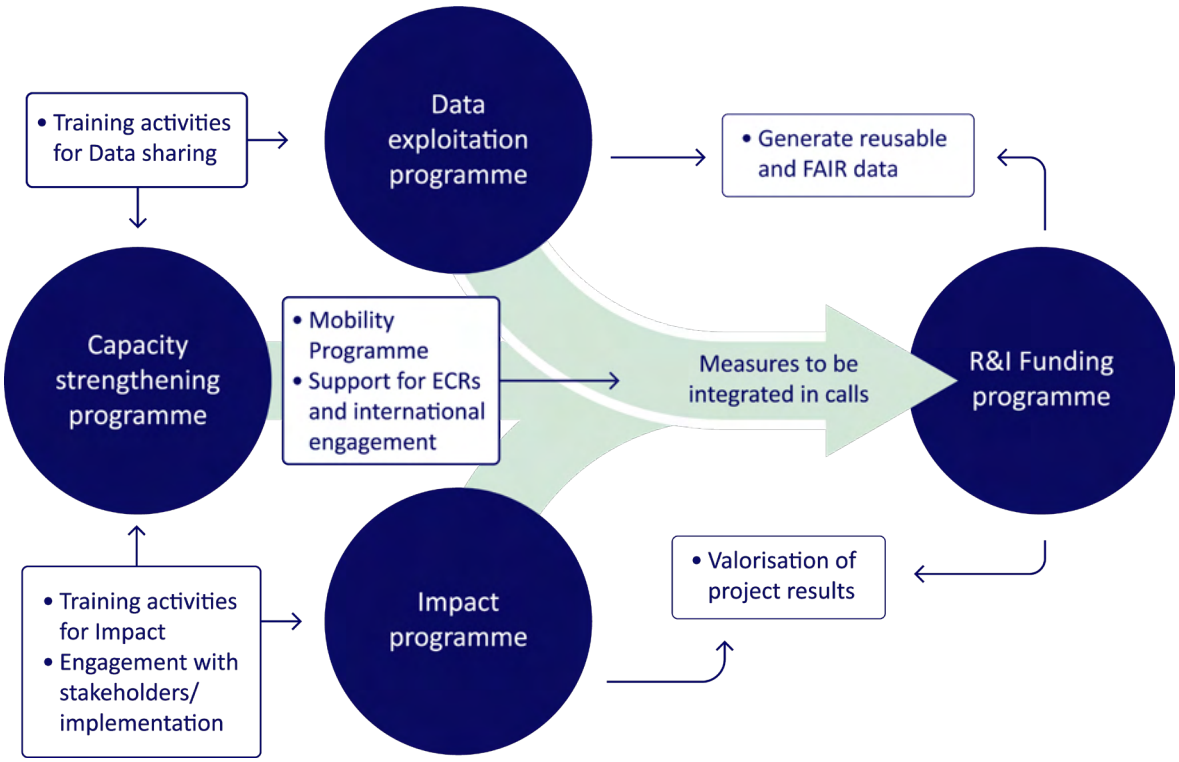


Figure 5. *The connections and cooperation areas of the four EUP OHAMR programmes.*

An annual work plan will be developed and detailed every year for the following year to describe the activities that will be performed by each programme. This will include the identification of topics and sub-topics for joint transnational R&I calls directed to one of the focus areas, as well as additional activities to strengthen research capacity, facilitate data (re)use and maximise impact. The prioritisation will rely on the needs expressed by the research community, by the stakeholders and by the EUP OHAMR partners, but also on the preliminary assessment of the activities organised during the past years, and on the resources available. The process will be coordinated to develop a coherent annual work-plan and to increase synergy between the different programmes across the different years.

The sections below briefly present the four programmes. More details on the different programmes can be found in the Roadmap of actions[55].

[55] Roadmap of action (2025-2032) of the EUP OHAMR

R&I Funding Programme

The objective of the R&I funding programme is to provide financial support to EUP OHAMR R&I through the organisation of annual competitive joint transnational calls co-funded by EUP OHAMR national/regional funding partner organisations and the EC. The R&I funding programme will cover the planning of the calls (selection of the scientific topics, funding instruments and measures to be integrated in the calls), their implementation (proposal submission and the selection process) and the monitoring of the funded projects. The launch of one joint transnational call is expected each year (exceptions with more than one call a year may exist). The calls will be opened to researchers and innovators at universities, hospitals, other research performing organisations, and private actors, covering a wide range of scientific disciplines. Inclusion of stakeholders (such as local authorities or patient associations) in the research consortia will also be welcome. The eligibility criteria will depend on the funding partner organisations engaged in the calls.

The calls will support different types of research and innovation activities (figure 6), including:

- Basic research projects - addressing fundamental research questions;
- Innovation, translational research projects - for research translation to technological development, proof of concept studies and innovations;
- Implementation research projects – testing evidence-based solutions and interventions assessing effectiveness in real world contexts;
- Networks to identify current knowledge gaps; identify new research questions and agree on common methods/ metrics/ guidelines. Networks could also support knowledge transfer, uptake of research results, practices and innovations and provide platforms for collaboration across OH sectors and disciplines.

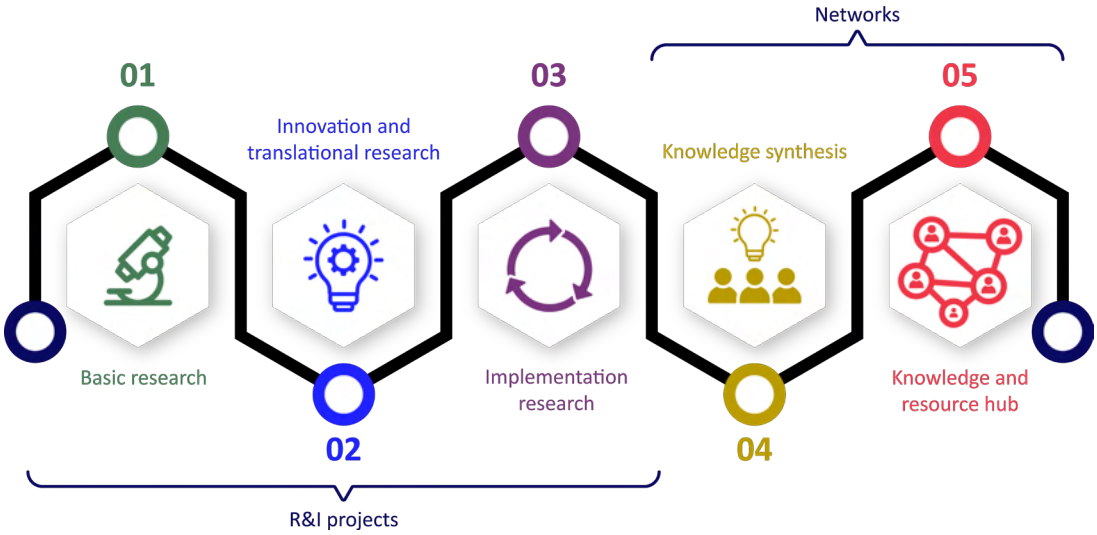


Figure 6. *Type of research and innovation activities covered by the call.*

In addition to the R&I activities, the call will also support additional activities aiming to support capacity strengthening, data/resources sharing, knowledge transfer and valorisation performed by the funded R&I consortia.

Separate peer review panels and multiple ranking lists will be used if needed to ensure a fair distribution of grant funding between different call topics and funding instruments.

Capacity Strengthening Programme

The capacity strengthening programme aims to strengthen the ERA and leverage the capacity of AMR researchers of different career stages and from diverse scientific backgrounds, OH sectors, professional domains (academia, industry, SMEs), gender and geographic origins (including widening countries and LMICs).

The objectives of the programme are:

- To leverage technical and non-technical skills needed to meet the AMR challenges
- To strengthen the collaboration, knowledge exchange and mobility between researchers of different scientific disciplines, OH sectors, professional domains and countries in EU and beyond
- Cultivate a viable and sustainable AMR research community, with a particular focus on empowering Early Career Researchers (ECRs) as integral contributors.
- Promote international engagement and research capacity strengthening in widening countries and LMICs, thereby addressing the global threat of AMR comprehensively

To realise the goals of the programme the following activities will be organised:

- Mapping of needs, barriers, actors and target groups for capacity strengthening
- Training activities (e.g. in advanced technologies, in project management, in scientific writing, in communication, in entrepreneurship, on data management, on pathway to impact)
- Activities to facilitate connections, collaborations, mobility and knowledge exchange across One Health sectors and different professional domains (academia, industry, SMEs), disciplines and countries (e.g. mobility programme, match-making events, conference, workshops to share good practice, directory of researchers)
- Activities to facilitate career progression of the early career scientists (e.g. establishment of a network of ECRs, mentorship programme, contests dedicated to ECRs)
- Activities to promote an international engagement (e.g. sharing of best practices, mobility)

The Capacity strengthening programme will work in close collaboration with the R&I funding programme to ensure the integration of capacity strengthening measures within the joint transnational calls (measures to promote ECR engagement, to promote the engagement of researchers working in widening countries and in low- and middle-income countries, to promote public/private sector collaborations, to enhance the formation of consortia including partners from different disciplines and OH sectors).

The programme is expected to result in the following outcomes:

- AMR researchers equipped with a comprehensive set of technical and non-technical proficiencies necessary to address the multifaceted challenge of AMR
- Stronger collaboration among AMR researchers and stakeholders, spanning diverse research disciplines, One Health sectors, SMEs, and industries, fostering a deeper comprehension of how each sector can contribute synergistically
- Establishment of a robust network comprising the upcoming AMR researchers, ready to confront the evolving AMR challenges
- Improved AMR research capacity within the EU and beyond, encompassing widening countries, and globally, extending support to Low- and Middle-Income Countries (LMICs), fortifying the collective global capacity to combat antimicrobial resistance

Data Exploitation Programme

The data exploitation programme will support the AMR community to facilitate sharing and (re)using of data and research infrastructures to foster an effective and efficient control and prevention of AMR. The programme will therefore work towards implementing the FAIR principles, as these guide the steps towards data to become findable, accessible, interoperable and reusable for both people and machines (computers). It will be done through subsequent and feasible steps, considering the level of reusability of data resources in the funded projects as well other resources. The ultimate goal would be that funded research and innovation projects produce (or use) FAIR data that remain at their source, that can be visited by algorithms, and be used by computer technology (data science, artificial intelligence). This would facilitate advanced analyses on large amounts of data, from different domains, disciplines and geographical areas. The programme will promote use and re-use of existing resources and research infrastructure relevant in the field of AMR covering the OH sectors. The main objectives of the programme are:

- To identify the stakeholders and users of AMR data and their needs to maximise the potential of data (re)use from various sources within the OH sectors to generate insights for research and policy;
- To identify the needs, barriers and solutions for availability, interoperability and reusability of AMR data resources and research infrastructure across OH sectors;

- To develop an operational structure and framework to support researchers and data stewards to produce reusable (and FAIR) data and to facilitate different type of users' access to AMR data and information;
- To facilitate access and cooperation of key AMR research and innovation infrastructures;
- To demonstrate how the produced (meta)data can be (re)used to tackle AMR research, policy or public health issues with a One Health approach.

To realise the goals of the programme the following actions will be undertaken:

- Engage the AMR community to identify the needs, resources and use of data in OH sectors to facilitate data harmonisation and interoperability.
- Engage the AMR community to identify the needs of use of AI based approaches including data mining and machine learning for advanced data analytics and insights on accelerating drug discovery, improving infection diagnosis and antibiotic prescription, and AMR surveillance for predicting disease outbreaks.
- Contact, liaise and collaborate with relevant infrastructures active in the EU and beyond to promote use and re-use of existing resources in the field of AMR.
- Develop data FAIRIfication framework so that data in the AMR research domain will be optimally produced, and made available for (re-)use for human and machine.
- Exploitation of the (meta)data to support AMR data use and reuse for policy and practice.

The programme is expected to result in the following outcomes:

- Better findability and access for the research community to AMR data and information on existing resources, and ability to use them in new and advanced research.
- Improved awareness and facilitating the research community to use and produce reusable (and as much as possible FAIR) AMR data with the help of standardised and machine-actionable descriptions of data and other resources.
- Improved opportunities for data science and artificial intelligence with FAIRified (meta)data, including advanced automated and integrated analyses on large AMR datasets from different domains, regions and OH sectors.
- Better interconnectivity of datasets from different OH-sectors to extract more value from existing data and to enable researchers, professionals, policy-makers and other stakeholders for data-informed decision-making to prevent and control AMR.

Impact Programme for knowledge mobilization

The impact programme will facilitate the transfer, uptake and valorisation of the knowledge generated from funded research and innovation projects for maximum societal impact. It aims to facilitate the translation of knowledge into solutions and policies and sustainable uptake of AMR interventions by providing a framework for collaboration between the knowledge generators (funded researchers and innovators as well as other AMR programmes and initiatives) and the knowledge-users, including policymakers, taking a One Health lens to mitigate AMR in diverse socio-economic settings. The objectives of the programme are:

- To support the identification of unmet needs, ensuring calls for research and innovation projects are informed by the relevant contexts, end-users, regulators and policymakers for generating evidence to create maximum impact.
- To provide practical tools, guidance and active support to facilitate translation and uptake of innovation and the implementation of evidence-based AMR interventions for sustainable impact.
- To ensure emerging outputs, outcomes and impacts from the EUP OHAMR are captured and disseminated for public benefit.

The programme is proposed to be executed by the “knowledge facilitators” who will act as intermediaries between the knowledge generators and relevant knowledge users and are expected to:

- Scope and identify unmet needs gaps, and opportunities to inform transnational R&I calls to generate evidence for maximum impact;
- Identify & map the added value and impact of R&I project findings for knowledge mobilisation;
- Facilitate the development of guidelines, recommendations and policy briefs where researchers and policymakers jointly contribute to use evidence to inform policy, programmes and practice;
- Promote engagement between researchers and innovators with regulators to enhance the understanding of regulatory principles of marketing authorization of medicine and to better inform the development of regulatory frameworks;
- Facilitate testing and implementing AMR-sensitive and -specific interventions supported through the R&I funding programmes;
- Provide support to R&I products (new leads, candidates, diagnostics, tools, technologies) to progress for further development.

The knowledge facilitators will deliver on actions and activities directed to three strategic tracks for innovation translation, implementation of evidence for practice and policy-making under the programme engaging the knowledge generators and the users. The programme will connect and engage with the existing actors and networks in the AMR field, globally, partner with diverse stakeholders tapping their experience and expertise and avoid duplication of efforts to accomplish the set objectives. The expected outcomes of the programme are:

- Better informed R&I calls delivering on research for unmet needs to generate evidence for societal impact.
- Equip researchers with translational knowledge to learn about the entire R&I ecosystem, value proposition, regulatory framework, end-users need and route to translation.
- Enhanced research impact through translation of research findings into sustainable solutions, products, services and knowledge-based policies made available for uptake and broad societal use.
- Deeper global cooperation and collaboration to maximise knowledge dissemination and translation.

Antimicrobial resistance genes enter aquatic systems via wastewater or through run-off to surface water and leaching to groundwater that can drive the development and spread of AMR from the environment to animals and humans.[56]

Monitoring of the progress of the EUP OHAMR towards its objectives

Monitoring the progress of the EUP OHAMR is vital to assess the progress of the partnership towards its goals, objectives and expected impact as well as for informing future actions.
The goals of the EUP OHAMR are reflected in the various general, specific and operational objectives in the following section. The outputs from the actions under each operational objective are expected to contribute to the outcomes of one or more specific objectives, which combined, will contribute to the expected impact generated from the general objectives as schematically represented in figure 7 and figure 8. Key performance indicators (KPIs) as proxies for measurement of progress towards the various objectives and defining the underlying impact pathways is necessary to assess the short and mid-term outputs and outcomes as well as longer-term socio-economic impact of the EUP OHAMR. The proposed KPIs, mentioned under each objective, include output indicators at the operational level that can be interpreted after a short term, as well as mid-term and long-term indicators for assessing outcomes and to demonstrate added-value, benefits and impacts for science and society. The proposed KPIs are complementary to the common indicators on the functioning of European Partnerships and Key Impact Pathways (KIPs) of the Horizon Europe (as referred to in Article III[57]).

[56] World Economic Forum: The costs and risks of AMR water pollution
[57] EU regulation establishing Horizon Europe – the Framework Programme for Research and Innovation

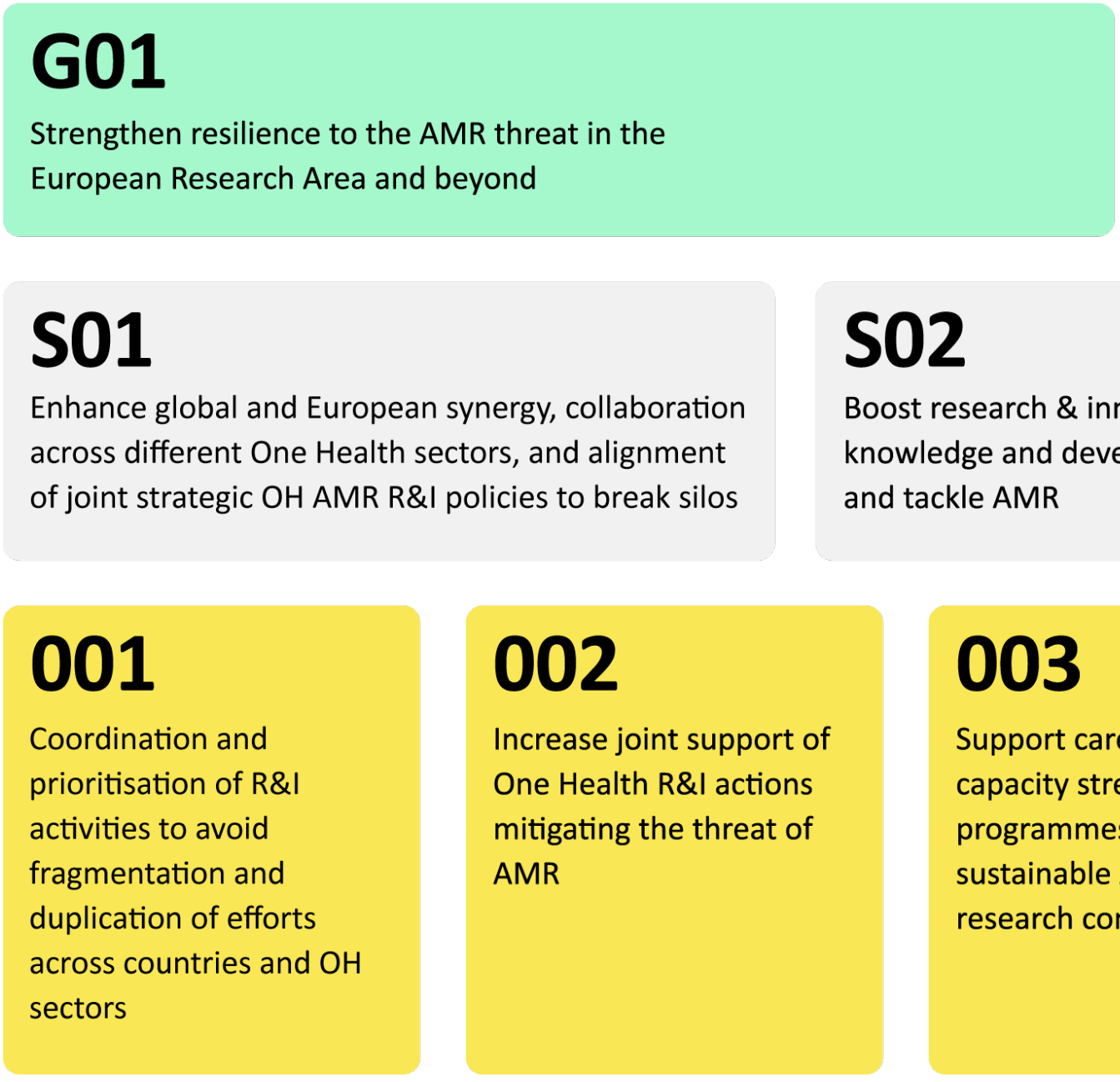


Figure 7. *General, Specific and Operational objectives of the EUP OH AMR. All objectives are interconnected and thus, each OO contributes to several SOs and each SO contributes to both GOs.*

G02

Enhance evidence-based policy measures and innovative solutions to prevent, detect, control, and treat drug-resistant infections in humans

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S03

Facilitate knowledge valorisation of research and innovation into products, policy and practice

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Facilitate access to AMR research resources platforms and enable sharing and (re)use of FAIR data

005

Support dissemination of research results for knowledge exchange, transfer and uptake by end-users

General objectives and their key performance indicators

The general objectives will provide a basis for assessing the partnership in relation to longer term and more diffuse effects (or global impacts). Indicators at this level are called impact indicators[58].

GO1. Strengthen resilience to the AMR threat in Europe and beyond

The EUP OHAMR will strengthen the resilience to the AMR challenge in the ERA by creating a structured AMR R&I ecosystem with stronger inclusion of the widening countries. This system will provide synergy and coordination of excellent basic research and innovation, increased capacity strengthening, programmes for the development of talent, and widening measures to increase the engagement of countries and stakeholders, as well as enhanced international collaboration to mitigate the threat from global hotspots of AMR.

Potential impact indicators for GO1:

- Strengthened global inter-sectoral and cross-border One Health AMR R&I ecosystem
  - Strengthened cooperation of the ERA to support R&I to combat AMR
  - Strengthened capacity (talent, knowledge, data, tools, resources) and integration of a One Health inter-sectoral and transdisciplinary AMR R&I ecosystem
  - Enhanced global collaboration for a strengthened OH approach to fight AMR expanded beyond Europe

GO2. Enhance evidence-based policy measures and innovative solutions to prevent, detect, control, and treat drug-resistant infections in humans

The EUP OHAMR will enhance research and innovation impact through translation of research findings, including data, and know-how into sustainable products, services, solutions and evidence-based policies made available for uptake and broad societal use to reduce the burden of AMR.

Potential impact indicators for GO2:

- Knowledge, evidence-based measures and innovative solutions put into action
  - Application of knowledge generated through cross-border, OH inter-sectoral and interdisciplinary R&I resulting in improved policies and understanding of AMR
  - Policy documents, guidelines, recommendations, strategic roadmaps generated utilising research evidence from funded R&I project results
  - Innovative solutions fulfilling unmet medical needs of human patients and animals, reducing the impact of AMR on food security and environment and contributing to the wellbeing of the society and delivering on EU meeting policy priorities and SDG objectives

[58] ERA Learn: Glossary of the most important terms for monitoring and evaluation.

Specific objectives and their key performance indicators

The specific objectives will provide a basis for assessing the partnership in relation to the short-term effects that occur. Indicators at this level are called outcome indicators.[58]

SO1. Enhance global and European synergy, collaboration across different One Health sectors, and alignment of joint strategic OH AMR R&I policies to break silos

The EUP OHAMR will mobilise and link key AMR stakeholders and provide a framework to break existing silos across One Health sectors and scientific disciplines in the AMR R&I landscape in the ERA, as well as globally. It will structure efforts to curb AMR and facilitate collaboration between different OH sectors and joint programming of actions between national and international, scientific and policy communities in coordination with industry, practitioners and end-users, with specific attention to widening countries and LMICs.

Potential outcome indicators for SO1:

- Alignment of R&I priorities and synergistic actions
  - Alignment with R&I priorities/objectives of the research action plans both at the EU level and with other international initiatives
  - New collaborations established within and beyond Europe across different disciplines and OH sectors
  - Synergies established with Widening countries and LMICs (country specific research management bodies/ AMR programmes) to enable R&I exchanges and cooperation.

SO2. Boost research & innovation to enhance knowledge and develop solutions to understand, prevent, and tackle AMR

The partnership will use a One Health interdisciplinary approach to prevent and treat drug resistant infections, improved surveillance, diagnosis and control of the spread of resistant microorganisms with integration of social sciences and interdisciplinary research and innovation.

Potential outcome indicators for SO2:

- R&I based knowledge generation and development of systems-wide solutions
  - Number of prediction models on risk assessment on AMR emergence and spread
  - Number of antimicrobial targets and candidates, therapeutic alternatives, new and improved diagnostics developed
  - Number of innovative products, processes or methods resulted (including IPR applications); creation of start-ups/companies as drivers of innovation
  - Number of evidence-based treatment regimens, stewardship measures and preventive solutions and mitigation measures developed

SO3. Facilitate knowledge valorisation of research and innovation into products, policy and practice

The EUP OHAMR will facilitate innovation translation and implementation of AMR-sensitive and -specific interventions supported through the R&I funding programmes into products, measures, solutions and development of evidence-based policy in the OH AMR domains.

Potential outcome indicators for SO3:

- Knowledge mobilisation for innovations and implementation
  - Improved dialogue and knowledge exchange between researchers, industry, data stewards, policymakers and other end-users
  - Number of original research articles, guidelines, recommendations, strategy roadmaps published (with open access status)
  - Number and type of R&I project outcomes (data, technical tools, protocols and guidelines) and resources generated and made available as FAIR in open platforms
  - Number of projects funded developing links between data/research resources or platforms/infrastructures across OH sectors and disciplines
  - Share of projects with R&I outcomes adopted for implementation of solutions/products and/or as base for creation of (start-up) companies
  - Scientific basis generated by the research projects for the development of potential regulatory framework/legislation proposals/policy
  - Number of products/innovations transitioning to an advanced TRL maturity in pipeline development
  - Number and types of R&I outputs that are disseminated in a format accessible for end users and citizens at large (e.g. videos, infographics, summaries, social media campaigns)

Operational objectives and their key performance indicators

The Operational objectives will provide a basis for assessing the partnership in relation to its outputs that is directly produced/supplied through the activities and actions carried out during the implementation process. Indicators at this level are called output indicators.[58]

OO1. Coordination and prioritisation of R&I activities to avoid fragmentation and duplication of efforts across countries and OH sectors

The EUP OHAMR will stimulate collaborative activities between EU and Member States, associated countries, LMICs and other international initiatives to increase commitment and investment for R&I actions. Regular/periodic meetings for information exchange with other partnerships/initiatives and stakeholders (including EC agencies) representing different

disciplines, OH sectors and professional domains within and outside Europe will be organised for stronger global cooperation. This information exchange platform will serve to identify prioritised R&I objectives targeted to the actual needs of the society (challenge-driven approach). The EUP OHAMR will also establish governance mechanisms assuring the maximum possible collaboration between organisations funding different OH sectors and disciplines and a broad range of stakeholders to capitalise on synergies and continue development of the joint SRIA/Roadmap of Actions.

Potential output indicators for OO1:

- Global stakeholder engagement
  - Establishment of a platform involving diverse stakeholders, policy makers, funders, donors from different countries (EU and non-EU), OH sectors and professional domains (academia and industry)
  - Membership growth (number and diversity of funding organisations including representation of the different OH sectors)
  - Joint investment committed for EUP OHAMR R&I actions
  - Diversity of engaged stakeholders (e.g. public, private, geographical and OH sector diversity)
  - Participation of Widening countries and LMICs

- Joint synergistic activities
  - Number and type of activities with other HE partnerships
  - Number and type of activities to facilitate synergies beyond Europe
  - Number of partnerships established between Europe, LMIC and widening countries research management bodies/ AMR programs
  - Continued development of the joint SRIA and roadmap of actions

OO2. Increase joint support of One Health R&I actions mitigating the threat of AMR strengthened through co-creation by end-users

This objective will reflect and encompass the One Health R&I actions through annual joint transnational calls to support cutting edge research with increased funding, new modalities and approaches, strengthening collaboration between different research disciplines and across different One Health settings.. The EUP OHAMR will support translational research for the development of (challenge-driven) innovative solutions as well as basic, and implementation research and innovation projects, research networks.. This objective will be further refined with detailed descriptions of R&I actions corresponding to the prioritised topics identified under the focus areas selected for calls and other activities integrating cross-cutting issues including socio-economic and global aspects, implementation science and innovation in R&I actions. Funded activities will be monitored by a structured framework for collection of research and innovations outputs and other relevant indicators

Potential output indicators for OO2:

- Joint activities and actions addressing prioritised EUP OHAMR R&I
  - Types and share of joint transnational calls and other R&I activities
  - Type of measures included in specific implementation research/stewardship/intervention trial calls and other activities for testing, validation and development of innovations and solutions
  - Number of transnational funded activities
  - Share of projects integrated cross-cutting issues including socio-economic aspects
  - Share of projects integrating different OH sectors
  - Share of projects which includes industry/SME
  - Share of projects where citizens and end-users contribute to the co-creation of the R&I content.

OO3. Support career and capacity strengthening programmes to create a sustainable AMR research community

The EUP OHAMR will utilise various funding instruments to support mobility, promote networking, collaboration, and knowledge exchange between researchers of different scientific disciplines, OH sectors, professional domains and countries in EU and beyond. Support for AMR researchers of different career stages and from diverse scientific backgrounds, OH sectors, and geographic origins is anticipated. Activities to strengthen research capacity in under-represented countries (including widening countries) and in LMICs is also anticipated to promote international engagement.

Potential output indicators for OO3:

- Upskilled researchers and strengthened research community
  - Share of research and innovation partners in funded projects representing different types of organisations (academic, industry, public health, civil society etc.)
  - Number of Early Career Researchers funded in research projects as well as undertaking mobility programmes, mentoring, training, and benefitting from capacity and career strengthening programme
  - Number of researchers funded from LMIC and widening countries
  - Knowledge transfer activities targeted to LMICs and widening countries
  - Number of transversal activities to promote collective mutual learning and exchange of knowledge and solutions between OH sectors and different professional domains (academia-industry) and countries

OO4. Facilitate access to AMR research resource platforms and enable sharing and (re)use of FAIR data

The EUP OHAMR will support the research community to use and produce reusable FAIR AMR data with the help of standardised and machine-actionable descriptions of data and other resources. Opportunities will be also explored to utilise data science and machine learning with FAIRified (meta)data for advanced automated and integrated analyses on large AMR datasets from different domains, regions and OH sectors. It will facilitate better findability and access for the research community to existing research infrastructure on AMR data and information.

Potential output indicators for OO4:

- Data sharing and (re)utilisation of resources
  - Number and type of activities to inform and engage researchers on available data platforms, research infrastructure, resources and tools for reuse and data sharing.
  - Number and type of activities to support researchers gain FAIR data-expertise through data stewardship training with data experts to generate FAIR research outputs.
  - Number and type of activities with the AMR community (domain and data experts) to identify modern tools/methods for data sharing and advanced data analytics.

OO5. Support dissemination of research results for knowledge exchange, transfer and uptake by end-users

Activities and events will be conducted to connect knowledge generators (the scientific community) with knowledge users (national, EU and international AMR policymakers, regulators, investors, industries, civil society organisations) to support knowledge exchange with end-users for further uptake into strategies, policies, regulations and practice. Furthermore, brokerage events to promote match-making between researchers, industry, incubators, accelerators and business angels will be organised, as well as activities to educate and inform researchers about innovation, policy, regulation and implementation needs. Researchers will also be informed about other funding opportunities that could support the further development of R&I products (new leads, molecules, diagnostics, tools, technologies. The EUP OHAMR will also organise activities and events to support societal engagement and disseminate research findings to a wider community, beyond the academic audience, including civil society organisations to create better awareness of AMR threats and solutions.

Potential output indicators for OO5:

- Community engagement and knowledge dissemination to end-users
  - Number and type of activities for engagement of projects with industry, regulators, policymakers, and other end-users for dissemination of research findings for innovation and translation
  - Number of activities on science - policy interface, science communication, citizen science etc involving researchers and end-users.
  - Number and type of stakeholders engaged in early engagement and dissemination activities (industry, regulators, policymakers, civil society) and other end-users

The EUP OHAMR pathway to impact

This section highlights the EUP OHAMR strategy map (figure 8) that will capture the relationships between the various activities, their implementation and the expected outcomes and pathway to impact including longer-term socio-economic impact through support of R&I actions. Many of the outcomes and the impact are expected to materialise even after the partnership has completed its activities. The indicators (as listed in the previous sections) forms the basis for measurement of progress and assessing the underlying impact pathway of the EUP OHAMR.

The EUP OHAMR will contribute to building a coherent European Research Area, reinforcing Member States, countries associated to Horizon Europe and the European Commission as internationally recognised driver to jointly support R&I on AMR. The EUP OHAMR will break the silos to form a strong OH research ecosystem linking the diverse stakeholders encompassing the human, veterinary, agricultural and environmental sectors. Through a joint strategic programming and global coordination of R&I, the EUP OHAMR will thus address various objectives of the EU One Health Action plan against AMR[59]. It will address the priority “making Europe more resilient” of the Horizon Europe Strategic Plan[60] by responding to the emerging threat of AMR.

By providing a better understanding of the transmission routes, magnitude, and directionality of resistant pathogens and resistant genes from animals/plants to human, and by designing new tools, and methods preventing this transmission, the EUP OHAMR will better inform the food chain system, including the food safety authorities, and the food producers, on the measures to be taken. Thus the EUP OHAMR will contribute to a sustainable transformation of health care, food production, the environment and society at large. The EUP OHAMR will contribute to the

[59] A European One Health Action Plan against AMR (2017)

[60] The Horizon Europe Strategic Plan 2021-2024

objectives of the Farm2Fork strategy[61], by promoting sustainable food production and enhance food safety and security, as well as the Zero Pollution Action Plan[62], by addressing the spread of AMR in the environment and thus address the objectives of the European Green Deal initiatives[63]. The EUP OHAMR will also address the objectives of the Pharmaceutical Strategy for Europe[64], in terms of fulfilling unmet medical needs on AMR and ensuring that the benefits of innovation reach patients in the EU and beyond. The EUP OHAMR will help unlock the potential of new tools, digital technologies and solutions and build towards a more harmonised data-enabled digital R&I environment for diagnosis, therapy, surveillance and prevention of AMR. Utilising data science and AI, the EUP OHAMR will support use of modern tools and technologies for advanced automated and integrated analyses on large AMR datasets from different disciplines and OH sectors and will contribute to Europe's strategy for digital transition[65]. By delivering increased knowledge, and evidence-based solutions to prevent and tackle AMR, the EUP OHAMR will thus contribute to making the EU a best-practice region on AMR. By coordinating national research efforts on AMR, in EU, but also beyond EU, the EUP OHAMR will also have an important role to shape the global Agenda, thus reinforcing Europe's leading role in the fight against AMR. The EUP OHAMR contribute to the UN SGD good health and wellbeing by decreasing the burden of infectious diseases due to antimicrobial resistant pathogens and preparing for emerging threats as depicted in the impact pathway map represented schematically in figure 8.

[61] The Farm2Fork Strategy (2020)

[62] EU Action Plan: "Towards a Zero Pollution for Air, Water and Soil" (2021)

[63] The European Green Deal

[64] A Pharmaceutical Strategy for Europe (2020)

[65] Shaping Europe's digital future

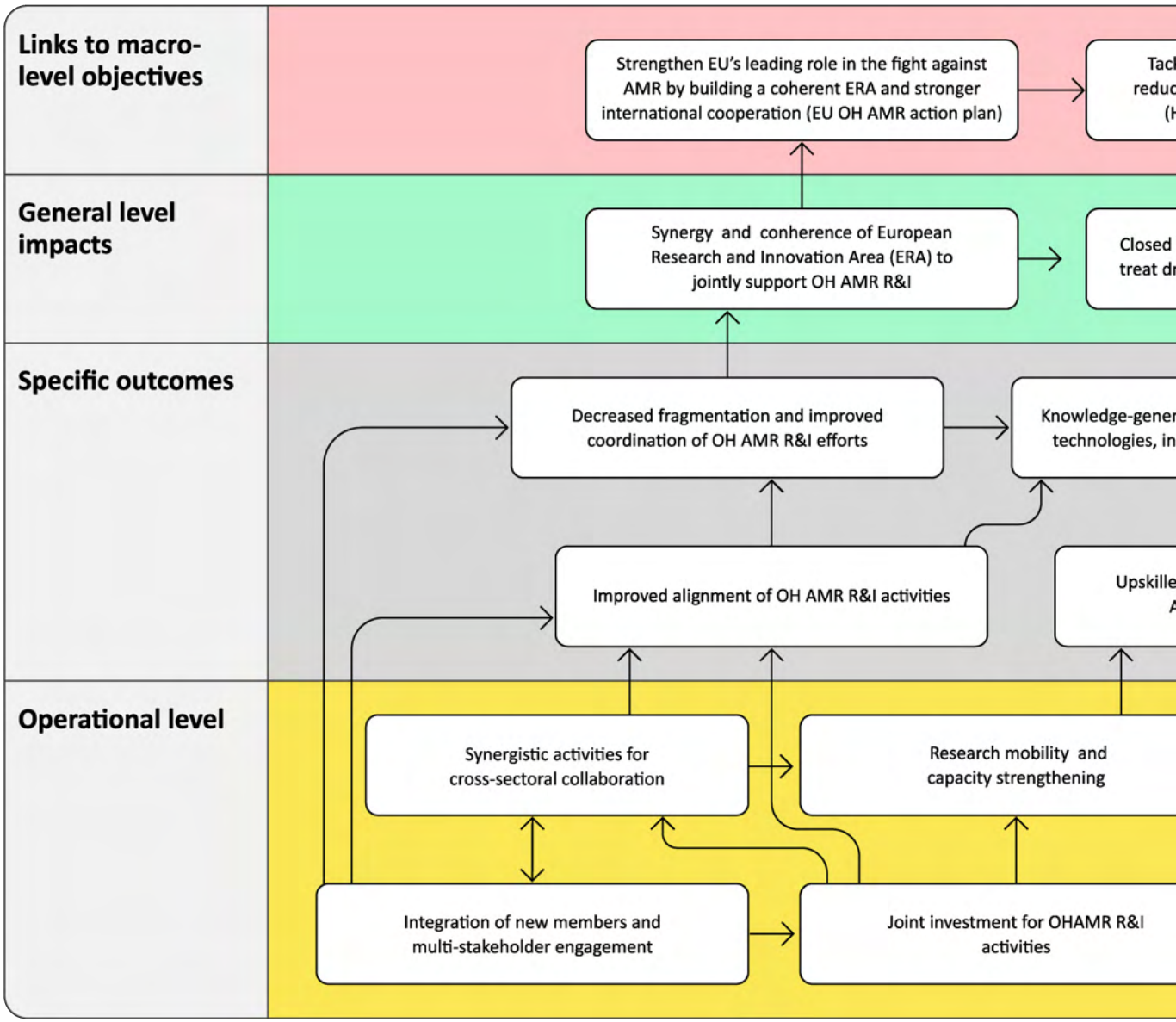
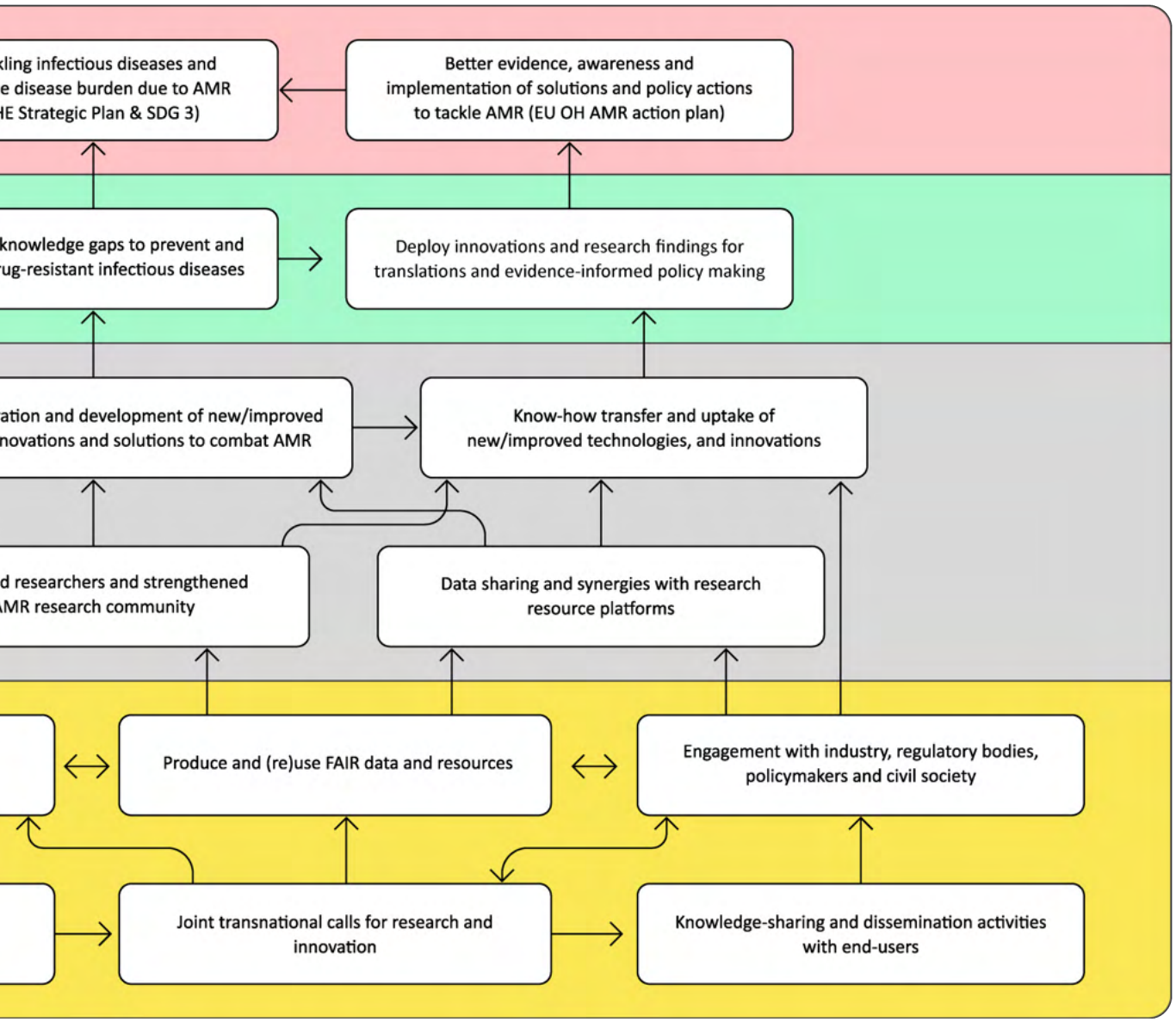


Figure 8. *The EUP OHAMR pathway to impact. The pathway links the resources of the EUP OHAMR and the actions to be undertaken towards specific outcomes to achieve multiple general objectives which then result in domain specific impact. All outputs are interconnected and thus, each contributes to several outcomes and each outcome contributes to different impact.*


kling infectious diseases and
e disease burden due to AMR
HE Strategic Plan & SDG 3)
Better evidence, awareness and
implementation of solutions and policy actions
to tackle AMR (EU OH AMR action plan)
knowledge gaps to prevent and
ug-resistant infectious diseases
Deploy innovations and research findings for
translations and evidence-informed policy making
ation and development of new/improved
novations and solutions to combat AMR
Know-how transfer and uptake of
new/improved technologies, and innovations
d researchers and strengthened
MR research community
Data sharing and synergies with research
resource platforms
Produce and (re)use FAIR data and resources
Engagement with industry, regulatory bodies,
policymakers and civil society
Joint transnational calls for research and
innovation
Knowledge-sharing and dissemination activities
with end-users

Synergies and Collaborations with other Partnerships, initiatives and Stakeholders

The AMR challenge cannot be solved by a single partnership. Synergies, complementarities and collaboration among the existing and planned partnerships and international initiatives are of utmost importance to address both AMR specific and AMR sensitive issues. The EUP OHAMR will thus engage with existing and emerging initiatives on a regular basis to identify synergies, plan potential joint activities and avoid duplication of efforts.

Overview of AMR related partnerships/initiatives

Synergies with other programmes and initiatives have been identified and listed in the table 1-4 below. The list should be seen as a preliminary and non-exclusive list and subject to development together with stakeholders and in relation to the emerging AMR landscape.

Table 1. Relevant European Partnerships within Horizon Europe Cluster 1 (Health).

Partnership	Objectives	Potential areas of synergy
Global Health European & Developing Countries Clinical Trials Joint Undertaking, (GH EDCTP 3-JU)	The Global Health EDCTP3 Joint Undertaking will support international research partnerships accelerating the clinical evaluation of drugs, vaccines and diagnostics for key infectious diseases affecting sub-Saharan Africa, as well as novel approaches for surveillance and control of emerging/ re-emerging infections in the region and globally. It will also strengthen clinical research capacity in sub-Saharan Africa.	• Alignment of capacity strengthening activities. • Alignment of calls, e.g. to address several parts of the therapeutic or diagnostic pipeline. • Joint workshops for dissemination and uptake of research results
Pandemic Preparedness	This partnership aims to improve the EU's preparedness to emerging infectious health threats by better coordinating R&I at EU, national (and regional) level, to develop solutions and tools to prepare, predict, prevent and respond to emerging infectious diseases and pandemic outbreaks, and to assure that research infrastructures (including Clinical trial platforms) could be ready to operate in case of pandemic.	• Alignment of calls, e.g. to address several parts of the therapeutic or diagnostic pipeline. • Alignment, or joint arrangement, of activities relating to antiviral or antiparasitic resistance.
Personalised Medicine, (EP PerMed)	The vision of the European Partnership for Personalised Medicine (EP PerMed) is to improve health outcomes within sustainable healthcare systems through research, development, innovation and implementation of personalised medicine approaches for the benefit of patients, citizens, and society.	• Joint activities relating to personalised antimicrobial therapies, e.g. capacity strengthening for professional groups or communication with regulatory agencies.

Partnership	Objectives	Potential areas of synergy
ERA for Health Research, (ERA4Health)	ERA4Health focuses on tackling diseases and reducing disease burden by addressing the following challenges: • The increasing demand for a better quality of life and a better patient care. • The need to transform public health care systems into more effective, efficient, equitable, accessible, and resilient ones. • The need to strengthen disease prevention and health promotion.	• Networking on a wide range of AMR specific and AMR sensitive issues, e.g. nanotechnologies for improved delivery of antimicrobials, continuity of the therapeutic pipeline, knowledge valorisation and bridging basic research with innovation.
Transforming Health and Care systems (THCS)	THCS aims to bring together stakeholders, create synergies, coordinate Research and Innovation actions, facilitate the digitization of health and care services and support the transformation of health and care systems with innovative solutions driven by knowledge and evidence.	• Joint activities for dissemination and implementation of relevant knowledge generated within EUP OHAMR on a large scale (given THCS's systems perspective).
Innovative Health Initiative Joint Undertaking (IHI JU)	This public private partnership aims to translate health research and innovation into benefits for patients and society. It covers prevention, diagnostics, treatment and disease management.	• Joint activities to highlight the continuum of the diagnostic and therapeutic pipeline, from basic research to product development.

Table 2. Relevant European Partnerships within Horizon Europe Cluster 6 (Food, Bioeconomy, Natural Resources, Agriculture and Environment).

Partenership	Objectives	Potential areas of synergy
EUP on Animal Health and Welfare (EUP-AH&W)	The EUP-AH&W's general goals are to progress Europe towards healthy and sustainable livestock production systems (for both terrestrial and aquatic animals), including the reduction of anti-microbial usage, and to greatly improve production animal welfare, in line with the European Green Deal and farm-to-fork strategy.	Alignment/coordination of calls and activities and planning of joint activities within: • Antimicrobial use and antimicrobial surveillance in livestock • Alternatives to antimicrobials (livestock) • Diagnostics of infectious diseases to be used in livestock • Vaccination against animal pathogens affecting livestock
Water4All – Water security for the planet	Water4All's Vision is to boost the systemic transformations and changes across the entire water research –innovation - implementation pipeline, fostering the matchmaking between problem owners and solution providers for ensuring water security for all in the long term.	Alignment/coordination of calls and activities and planning of joint activities within: • Accumulation of antimicrobial residues in water • Decontamination strategies.
Safe and Sustainable Food Systems for People (PSFS)	The overarching vision of the SFS Partnership is that its actors collectively will achieve environmentally-friendly, socially secure and fair, economically viable, healthy and safe food systems in Europe in order to help realise its goals of the Farm to Fork strategy, in line with the global ambitions of United Nations (UN) Sustainable Food Summit 2021.	Alignment/coordination of calls and activities and planning of joint activities within: • AMR transmission (livestock/crop to human).

Partenership	Objectives	Potential areas of synergy
Accelerating farming systems transition: agroecology living labs and research infrastructures	The partnership aims to accelerate the transition towards sustainable, climate- and ecosystem-friendly farming practices. To do so, it will 1) enable a better comprehension of agroecological processes from farm to landscape levels, 2) boost place-based innovation in co-creative environments and 3) improve the flow and uptake of knowledge and innovations on agroecology.	Alignment/coordination of calls and activities and planning of joint activities within: • Use of antimicrobials in Agri-Food systems

Table 3. Relevant European Initiatives within other EU funding programmes/clusters.

Initiative	Objectives	Potential areas of synergy
Joint Action on Antimicrobial Resistance 2 (EU-JAMRAI 2)	EU-JAMRAI 2 will support MS/AC (Member States/Associated Countries) in their efforts to develop and update their National Action Plans on AMR, contributes to several EU4Health policy priorities by strengthening MS/AC coordination and responsiveness against AMR, ensuring the access to important medicinal products and medical devices and, protecting people from AMR.	• Uptake of research results by European policy makers and end-users
EIT Health	The ambition of EIT Health is to enable people in Europe to live longer, healthier lives. The work goes beyond conventional approaches to disease management and disease prevention. EIT Health is building and growing businesses to create products and services that progress healthcare in Europe, while strengthening the economy.	• R&I uptake by SMEs and Industry and training activities.
European Open Science Cloud (EOSC)	The ambition of the European Open Science Cloud (EOSC) is to provide European researchers, innovators, companies and citizens with a federated and open multi-disciplinary environment where they can publish, find and re-use data, tools and services for research, innovation and educational purposes.	• Access and sharing of data.

Table 4. Relevant EC General directorates, EU agencies and EU Institutions

Organisation	Objectives	Potential areas of synergy
EC general directorate for Research and Innovation (DG RTD)	This Commission department is responsible for EU policy on research, science and innovation, with a view to help create growth and jobs and tackle our biggest societal challenges	• EU strategy, policies, recommendations and actions on antimicrobial resistance • Future updates of SRIA
EC general directorate for Health and Food Safety (DG Santé)	This Commission department is responsible for EU policy on food safety and health and for monitoring the implementation of related laws.	• EU strategy, policies, recommendations and actions on antimicrobial resistance • Future updates of SRIA
EC general directorate for Agriculture and Rural Development (DG AGRI)	This Commission department is responsible for the EU Commission's policies on agriculture, rural development and the common agricultural policy (CAP).	• EU strategy, policies, recommendations and actions on antimicrobial resistance • Future updates of SRIA
EC general directorate for Health Emergency Preparedness and Response Authority (HERA)	HERA anticipates threats and potential health crises, through intelligence gathering and building the necessary response capacities.	• EU strategy, policies, recommendations and actions on antimicrobial resistance • Future updates of SRIA
European Centre for Disease Prevention and Control (ECDC)	Its mission is to identify, assess and communicate current and emerging threats to human health posed by infectious diseases.	• AMR &AMU Surveillance • Future updates of SRIA • Awareness and outreach activities
European Food Safety Authority (EFSA)	Its mission is to assure the safety in the food chain from farm to fork	• Zoonotic bacteria present in animals and food • Future updates of SRIA • Awareness and outreach activities
European Medicines Agency (EMA)	Its mission is to is to evaluate and supervise medicines, for the benefit of public and animal health in the European Union	• Regulation and approval (antimicrobials and alternatives to antimicrobials) • Future updates of SRIA • Awareness and outreach activities

Organisation	Objectives	Potential areas of synergy
European Environment Agency (EEA)	The agency aims to we provide the knowledge and the data needed to achieve sustainability in Europe	• Water and environment pollution by antimicrobial residues and resistant pathogens • Future updates of SRIA • Awareness and outreach activities
One Health cross-agency task force	The task force will support the implementation of the One Health agenda	• One Health AMR Action Plan

In addition to the European stakeholders listed above, the EUP OHAMR will also interact with a wide range of international stakeholders having an interest on AMR: WHO, the UN Quadripartite (including the AMR Multi-Stakeholder Partnership Platform), the Global Leaders Group on Antimicrobial Resistance (AMR Leaders), the Global AMR R&D Hub, the STAR-IDAZ International Research Consortium, the MedVetNet Association, the Biotech companies from Europe innovating in Anti-Microbial resistance research (BEAM) Alliance, the European Federation of Pharmaceutical Industries and Associations (EPFIA), Action on Antibiotic Resistance (ReAct), International Centre for Antimicrobial Resistance Solutions (ICARS), the Fleming fund, Wellcome, Bill & Melinda Gates Foundation, Team Europe Initiative Africa, Global AMR Innovation Fund (GAMRIF), the Combating Antibiotic Resistant Bacteria Biopharmaceutical Accelerator (CARB-X), the Global Antibiotic Research & Development Partnership (GARDP), FIND and the AMR Action fund.

The EUP OHAMR will also connect with the society by collaborating with the AMR Stakeholder Network, established at the European Public Health Alliance (EPHA), which brings together more than 60 leading organisations and individuals, including patient groups, health professional organisations, NGOs for public health, veterinarians etc. at national, regional and European level and thus is an excellent platform for stakeholder engagement, to advice on societal needs and facilitation of uptake of research results and solutions. Social science networks like the International Network for AMR Social Science (INAMRSS) will also be important to engage with.

Finally, the EUP OHAMR will also collaborate with training providers, such as the European Society of Clinical Microbiology and Infectious Diseases (ESCMID) and EIT Health, as well as with existing research infrastructures and data sharing initiatives, such as the European life-sciences infrastructure for biological information (ELIXIR), The Microbial Resource Research Infrastructure (MIRRI), Biobanking and Biomolecular Resources Research Infrastructure (BBMRI), GO FAIR and the European Health Data Space (EHDS).

Plans for future collaboration

Within the EUP OHAMR, synergies will be addressed on a strategic level as well as in concrete programme activities. The partnership will entail activities for strategic development (e.g participation in global and European collaborative efforts), ensuring that the partnership serves its overall purpose by generating knowledge that is relevant for the whole AMR ecosystem. The EUP OHAMR stakeholder network will build on the relationships existing between the JPIAMR and a broad range of AMR stakeholders. Participation in the AMR Multi-Stakeholder Partnership Platform, alignment of strategic research agendas with the WHO and the quadripartite, launch of a joint call for projects with the JPI Ocean and Water, organisation of a joint workshop with the JAMRAI represent some of the concrete activities resulting from the collaboration between the JPIAMR and some AMR stakeholders. A decision matrix will be employed addressing relevance, feasibility and efficacy to guide the engagement and collaboration process to ensure that resources are efficiently managed.:

- To establish the EUP OHAMR strategy: Regular interactions with stakeholders will be fundamental to map the needs of the end-users and policy makers, to align research strategies, and to identify potential research gaps and overlaps, and to plan common activities. A stakeholder forum regrouping a wide range of EUP OHAMR stakeholders will meet regularly to reach strategic consensus. The stakeholder forum will also be consulted ahead of the drafting of the annual workplan and of the call topic selection. In addition, bilateral meetings will be organised to discuss specific topics of interest.

- To implement the EUP AMR actions: The EUP OHAMR will implement specific activities responding to the needs expressed by stakeholders and end-users. In addition, when topics are of common interest for the EUP OHAMR and EUP OHAMR stakeholders, joint (i.e. workshops, roundtables, training) or coordinated (i.e. calls) activities will be organised. The EUP OHAMR will also continue to participate in activities and networks organised by the other partnerships with the purpose of identifying and addressing synergies.

- To facilitate translation and uptake of the research results: The EUP OHAMR will promote the dissemination of the research results obtained by the funded activities through the organisation of an annual or bi-annual conference. These events will also represent an opportunity for the stakeholders to highlight some of the tools, methods, and practise that were developed in their own initiative and that could be beneficial for the EUP OHAMR research community.

Annex 1. SRIA development process and plans for update

Development Process

The current SRIA has been developed by the Coordination and Support Action (CSA) DESIGN OH AMR funded by the European Union (Grant Agreement N°101057036), in close collaboration with the JPIAMR Scientific Advisory Board and other experts (see the list below), the JPIAMR member states and the countries who expressed their interest to join the EUP OHAMR.

Each section of the SRIA has been developed separately. The different sections were then combined into a single document by the drafting team. A first version of the SRIA was subjected to a consultation (survey) directed to partners that had expressed interest to join the EUP OHAMR and some of the key stakeholders (eg EU agencies and other partnerships) in April 2023. A second version of the document was subjected to a second open consultation (survey) in May 2024. This second consultation was publicly opened and advertised through JPIAMR communication channels (newsletter, social media and website), through national communication channels, and through EPHA (The AMR Stakeholder Network) communication channels. The participation of academic researchers, end-users, SMEs, industry and stakeholders (including other partnerships, EU initiatives and agencies, and EC directorates) was encouraged. Efforts were made throughout the process to consider the needs expressed by different OH sectors (Human Health/Agriculture/Environment) and professional domains (Academic/SME/Industry) and by different disciplines. The SRIA has been drafted in collaboration with the WHO and the quadripartite organisations[66] to ensure an alignment with their respective AMR agenda[67],[68]. The EUP OHAMR partners endorse the content of the SRIA. The EUP OHAMR SRIA will guide the actions of the EUP OHAMR.

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Experts directly consulted during the development process (by alphabetic order):

[66] The Quadripartite organisations: the Food and Agriculture Organization of the United Nations (FAO), the United Nations Environment Programme (UNEP), the World Health Organization (WHO) and the World Organisation for Animal Health (WOAH)

[67] WHO Global research agenda for antimicrobial resistance in human health (2023)

[68] Quadripartite A one health priority research agenda for antimicrobial resistance (2023)

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Additional experts have been consulted, such as the Social Sciences working group:

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SRIA Update

An update of the EUP OHAMR SRIA is planned three years after the launch of the partnership. The update can be advanced if a need is expressed by the EUP OHAMR partners. The update will be based on the KPI assessment, on the recommendations formulated by the EUP OHAMR Scientific Advisory Board and by the EUP OHAMR stakeholders. During the process, consultation (s) opened to academic researchers, SME/ Industry, end-users, country-representatives and stakeholders will take place.

Abbreviations

AI	Artificial Intelligence
AMC	Antimicrobial consumption
AMR	Antimicrobial Resistance
AMU	Antimicrobial Use
CSA	Coordination and Support Action
EC	European Commission
ECDC	European Centre for Disease Prevention and Control
ECR	Early Career Researcher
EEA	European Environment Agency
EFSA	European Food Safety Authority
EMA	European Medicines Agency
ERA	European Research Area
ERA4Health	ERA for Health Research
EU	European Union
EUP AH&W	European Partnership on Animal Health and Welfare
EUP OHAMR	European Partnership on One Health AMR
FAIR	Findable, Accessible, Interoperable and Reusable
FAO	Food and Agriculture Organisation of the United Nations
GDP	Gross domestic product
GH EDCTP3 JU	Global Health European & Developing Countries Clinical Trials Partnership Joint Undertaking
GO	General objective
HERA	Health Emergency Preparedness and Response Department
IACG	Interagency Coordination Group on Antimicrobial Resistance
JAMRAI	Joint Action on Antimicrobial Resistance
JPIAMR	Joint Programming Initiative on AMR
JTC	Joint transnational call
KPI	Key Performance Indicators
LMIC	Low- and middle-income country
NGO	Non-governmental organisations
OH	One Health
One Health EJP	One Health European Joint Programming
OO	Operational objective
R&I	Research and innovation
SDG	Sustainable Development Goal

SME	Small and medium-sized enterprise
SRIA	Strategic Research and Innovation Agenda
SO	Specific objective
UN	United Nations
UNEP	UN Environment Programme
WHO	World Health Organization
WOAH	World Organisation for Animal Health

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