AMR EDUCare

Recommendations on digital skills and Behavioural change for AMR

(Deliverable 5.2)

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1. Executive Summary

This report, developed under Work Package 5 of the AMR EDUCare project, represents a direct continuation of Deliverable 5.1, which presented key findings from the literature and stakeholder consultations regarding the role and identification of IT tools and digital skills in supporting behaviour change in the context of antimicrobial resistance (AMR). While the previous deliverable offered the conceptual and theoretical foundations and insights from stakeholder consultation on which the project content was developed, drawing from behavioural science frameworks and digital health taxonomies, this report moves from theory to application.

Following on deliverable 5.1., deliverable 5.2 outlines the comprehensive methodology used to integrate behaviour change tools and digital skills into training programmes for healthcare professionals. It provides detailed accounts of the implementation process, including training design, course development, and participant engagement. Furthermore, it presents practical recommendations for embedding digital competencies and behavioural science principles into AMR education.

The key contributions of this report include:

- Practical insights into barriers and facilitators of digital tool adoption among healthcare professionals;
- Recommendations for integrating digital literacy and behavioural change strategies into national and European health curricula;
- Empirical findings from training implementation of learning material under the AMR- EDUCare project.

Findings highlight the need for targeted, context-sensitive interventions that support both technological adoption and sustainable behaviour change. The effective use of IT tools in AMR contexts depends not only on access to infrastructure, but also on the professional competencies, motivation, and

institutional support that enable meaningful engagement.

This report serves as both a practical guide and a strategic resource for educators, policymakers, and healthcare organisations aiming to modernise AMR training through the integration of digital innovation and behavioural science. It reinforces the importance of a dual approach, technological and behavioural, to equip the health workforce with the necessary tools and mindsets to respond to the growing global threat of antimicrobial resistance.

2. Introduction

AMR is a mounting challenge to global health, undermining the effectiveness of treatments and placing increasing strain on healthcare systems. Addressing AMR requires a multifaceted response that spans regulatory frameworks, clinical practice, technological innovation, and, critically, behavioural transformation. Despite the wealth of scientific evidence and treatment guidelines available, the persistent gap between knowledge and practice remains, often driven by habits, routines, and institutional barriers.

Equipping the healthcare workforce with appropriate digital skills and tools to foster behavioural change has become a cornerstone of effective antimicrobial stewardship. This report builds on Deliverable 5.1: Development of Behavioural Change Tools (AMR EDUCare Project, WP5 Digital health skills and behavioural change), which reviewed the literature on behavioural frameworks such as the COM-B model and the Behaviour Change Wheel (BCW), and explored the potential of digital tools to influence prescribing practices, diagnostic decisions, and public engagement. Rather than revisiting that literature in detail, the present report takes the work further by focusing on how digital competencies can be developed and how behavioural change can be embedded into practice.

Central to this discussion is the recognition that digital tools, such as decision support systems, educational platforms, and mobile applications, can only be effective if users possess the necessary skills to apply them meaningfully. Building digital competence requires not only technical proficiency (e.g., managing data, using software) but also soft skills (e.g., digital communication, empathy in remote consultations). Ensuring equitable access to these tools and training opportunities, particularly in rural or resource-constrained settings, is equally vital to prevent deepening healthcare inequities.

Within the broader goals of the AMR EDUCare project, this report situates digital skills development as integral to supporting sustainable behavioural change among healthcare professionals. Digital transformation is not simply about introducing new technologies, but about enabling people, including clinicians, patients, and

policymakers—to use them effectively in their daily contexts.

Drawing directly on the insights from Deliverable 5.1, the methodological approach presented here connects behavioural science, digital competence frameworks, and the realities of AMR management. The following section outlines how this approach was applied to design and implement antimicrobial stewardship training that integrates both digital skills and behavioural change strategies

Throughout this report, we distinguish between behavioural change strategies and behavioural change tools. Strategies refer to the broader, theory-driven approaches that guide intervention design, drawing on frameworks such as the COM-B model and the Behaviour Change Wheel (e.g., targeting capability, motivation, or opportunity). Tools, in contrast, are the concrete applications developed to put these strategies into practice, such as checklists, infographics, commitment statements, or digital decision aids. While closely related, strategies provide the conceptual rationale, and tools represent their practical implementation. This distinction is applied consistently in the following sections.

3. Methodology

This section presents the methodology employed in the implementation of tasks 5.1, 5.2 and 5.3. under Work Package 5 (WP5 on Digital health skills and behavioural change) of the AMR-EDU Care project. The approach focused on (1) identifying and integrating behavioural change tools to support antimicrobial resistance (AMR) mitigation strategies, and (2) mapping and embedding digital skills and tools relevant to AMR across professional training content.

3.1. Methodology for Behaviour Change Tools

The identification and development of behavioural change tools to support antimicrobial resistance (AMR) mitigation within the European health workforce followed a structured and theory-informed approach based on the **Intervention Mapping (IM) protocol** developed by Bartholomew et al. (2011). This model, widely recognised in public health and behavioural sciences, offers a systematic and iterative framework for designing interventions that are both evidence-based and contextually grounded. Its selection was instrumental in ensuring methodological rigour, alignment with stakeholder realities, and practical applicability in diverse health systems.

The intervention mapping approach unfolded in five steps. **Step 1** involved a needs assessment to identify behavioural drivers of inappropriate antimicrobial use. **Step 2** translated these findings into clear behavioural change objectives, linking individual prescribing practices with systemic enablers. **Step 3** applied the COM-B model to map these objectives to behavioural determinants of capability, opportunity, and motivation, guiding the selection of suitable behaviour change techniques. **Step 4** focused on the design of training modules and supporting tools, grounded in adult learning principles. **Step 5** developed the implementation strategy to ensure integration, piloting, and scalability. These steps are presented in greater detail in the following section.

A visual representation of the process is provided in Figure 1, illustrating the methodological flow, interdependencies between phases, and how each step fed

into the design and implementation of the intervention.

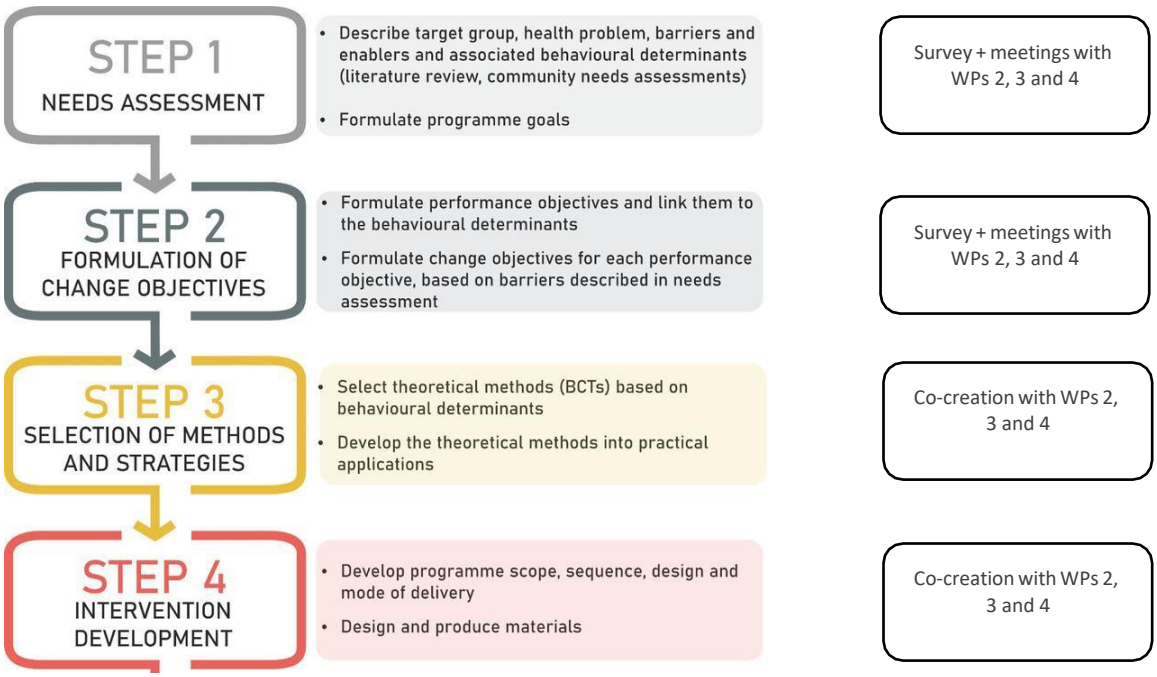

Figure 1 – Intervention mapping process (Dieberger et al., 2021; Weil et al., 2023)

Preliminary Literature Review

Prior to initiating the core steps of the IM framework, a **scoping review of the existing literature** focused on the mapping and analysis of behaviour change models and tools was conducted (see deliverable 5.1).

This preliminary phase revealed the frequent use of models such as the **COM-B system** and the **Behaviour Change Wheel**, and highlighted techniques with demonstrated effectiveness, including audit and feedback, reminders, peer benchmarking, and case-based training. It also uncovered persistent gaps, particularly regarding the interdisciplinary adaptation of interventions and the limited contextual tailoring of tools to frontline realities. These findings informed the conceptual framework of the subsequent intervention development process.

Step 1: Needs Assessment

The first stage involved a multi-layered diagnosis of behavioural drivers and barriers linked to inappropriate antimicrobial use. The target population was defined to include physicians, nurses, pharmacists, and health managers, all playing critical roles in the decision-making processes related to antibiotic use.

Empirical data were collected through the three co-creation focus groups, described in deliverable 5.1. A total of 31 healthcare professionals working in Portugal (12 nurses, 10 pharmacists, and 9 physicians) participated.

Thematic analysis of the transcripts identified recurring behavioural patterns contributing to AMR, including empirical prescribing without diagnostic confirmation, limited adherence to clinical guidelines, and the influence of patient pressure in prescribing decisions. These behaviours were further examined in terms of their underlying causes, which included knowledge gaps, time constraints, organisational norms, and misperceptions about antibiotic efficacy. Context-specific behavioural profiles were created and subsequently used to tailor the design of training modules.

The needs assessment identified knowledge gaps, time constraints, and misperceptions as core barriers. These insights directly informed the recommendations: knowledge gaps are addressed through pre- and post-quizzes, brochures, and infographics; time constraints are mitigated through concise decision aids and quick-reference guidelines; and misperceptions are tackled via simplified communication strategies and repeated key messages across modules. In this way, the recommendations explicitly translate the diagnostic findings into practical tools.

Step 2: Defining Behavioural Change Objectives

The second step translated the diagnostic insights into clear, measurable behavioural change objectives. This began with the identification of target behaviours, such as appropriate antibiotic prescribing or active patient

engagement, followed by the specification of performance objectives that articulated what professionals should do differently.

For example, in the case of prescribing behaviour, specific objectives included: correctly identifying situations where antibiotics are not indicated, consulting relevant clinical guidelines, and communicating evidence-based rationales to patients. In parallel, the team identified environmental and systemic outcomes necessary to support these behaviours, including access to decision-support tools.

While prescribing behaviour was the main example provided, additional objectives were also defined, including: improving patient engagement (e.g., use of plain language and visual aids during consultations), enhancing waste management practices (e.g., adoption of standardized disposal protocols), and fostering inter-professional communication (e.g., protocol negotiation with managers). These objectives are reflected in the recommendations by the inclusion of patient empowerment materials, case studies on improper disposal, and tailored modules for different professional audiences.

This dual focus, on individual behaviour and environmental enablers, allowed the training to move beyond awareness-raising and target the broader ecosystem in which prescribing decisions are made.

Step 3: Selection of Behavioural Methods

The behavioural objectives identified in Step 2 were mapped against the COM-B model to diagnose whether they were primarily constrained by issues of capability (e.g., lack of knowledge or skills), opportunity (e.g., time, institutional support), or motivation (e.g., attitudes, beliefs, intentions).

This analysis informed the selection of behaviour change techniques (BCTs) that were both theoretically sound and practically feasible within the training context.

The selection of Behaviour Change Techniques (BCTs) provided the backbone for the recommendations. For instance, educational content and structured feedback underpin the recommendations under “Targeting Capability”; persuasive

messaging, modelling, and goal-setting appear under “Targeting Motivation”; while commitment statements and nudges are mirrored in the recommendations that link motivation and opportunity. This ensures that the BCTs selected are consistently operationalised within the recommended tools and practices.

Examples include:

- Educational content to enhance psychological capability.
- Structured feedback to support reflective practice.
- Simulation exercises and case-based learning to build applied skills.
- Environmental restructuring through the integration of decision aids.

Where motivational factors were significant, such as low perceived impact of individual actions on AMR, techniques like persuasive messaging, social modelling, and value framing were incorporated. The outcome was a comprehensive matrix linking behavioural determinants, change methods, and training activities.

Step 4: Training Design and Tool Development

This stage involved the development of the training modules, based on the logic model established in the previous phases. Each module was designed to target specific behavioural outcomes, incorporating adult learning principles such as relevance, experiential learning, and practical application.

The training content was enriched with:

- Interactive elements to foster engagement and reflection.
- Clinical vignettes and decision-making scenarios rooted in real-world practice.
- Feedback loops that enabled users to self-assess and receive guidance.

Additionally, supporting materials were developed to reinforce learning and facilitate on-the- job application. These included quick-reference guidelines, checklists, infographics, and structured decision aids. Special attention was paid to the adaptability of the materials to local policies, and professional cultures, ensuring cross-country relevance without sacrificing specificity.

The training design translated the methodological steps into concrete outputs. In total, 15 modules were developed: 9 in WP2 (Antimicrobial prescribing optimization), 3 in WP3 (Antimicrobial waste reduction and management), and 3 in WP4 (patient empowerment). All were updated to integrate behaviour change tools and digital skills as outlined in the recommendations. For example, prescribing modules incorporated checklists and clinical vignettes, waste management modules introduced blockchain-based tracking scenarios, and patient empowerment modules embedded visual guides and gamified apps. These updates ensured that the methodological design was mirrored in the final recommendations and learning resources.

Step 5: Implementation Strategy

The practical implementation of the behavioural change tools is detailed in Chapter 4, including the integration into professional development systems, pilot testing in selected settings, and strategies for dissemination and scalability across the participating countries.

In practice, the behavioural change tools identified in Steps 1–3 were embedded throughout the training modules and delivery formats. For example, capability-focused tools (pre- and post-quizzes, quick-reference guidelines, visual infographics) were integrated into prescribing and patient empowerment modules. Motivational tools (goal-setting, summarising key messages, modelling through clinical vignettes) were incorporated into simulation exercises and interactive case studies. Opportunity-enhancing tools (commitment statements, nudges such as on-screen reminders) were applied through the digital platform and workshop activities. These elements ensured that the behavioural change techniques (BCTs) moved beyond theory into the daily learning experience of healthcare professionals. Section 4.1 therefore illustrates not only the training logistics but also how behavioural change methods were operationalised within course content and participant engagement.

Timeline and Integration with Work Packages

The methodological steps unfolded in an overlapping sequence to allow iterative refinement:

- **Steps 1 and 2** were conducted between July 2023 and December 2023, directly informing the content development in Work Packages 3 and 4.
- **Steps 3 and 4** spanned from April 2023 to June 2024, with iterative cycles of content creation, stakeholder feedback, and technical development.

3.2. Methodology for Introduction of IT Tools and Skills

In parallel, a structured and participatory methodology was used to map digital skills and tools relevant for AMR management, aligned with the EU Digital Competence Framework (DigComp 2.1) and European One Health action plans.

Step 1: Needs Assessment

This involved using a structured survey and co-creation workshops to assess digital skills, tools, and challenges faced by health professionals across medicine, nursing, pharmacy, and healthcare management.

The structured survey was completed by 90 healthcare professionals (35 nurses, 33 physicians, 8 pharmacists, 7 radiologists, 7 administrators) to assess digital literacy, tool usage, and perceived barriers. Key variables measured included confidence with digital platforms, perceived usefulness, and institutional support for digital training.

Empirical data relevant to the integration of IT tools was also collected through the three co- creation focus groups described in step one of the methodology for behavioural change tools in which 31 health professionals participated (12 nurses, 10 pharmacists, 9 physicians).

Step 2: Content Co-Development and Integration

Following the workshops, WP5 led a structured alignment process with WP2 (Antimicrobial prescribing optimization), WP3 (Antimicrobial waste reduction and management), and WP4 (Patient empowerment) to co-design educational content. Digital skills content was modularised and structured according to DigComp 2.1 proficiency levels and incorporated practical application scenarios. Specific examples of inter- package integration include:

- WP2 (Antimicrobial Prescribing optimization): A shared case study on AI-driven Clinical Decision Support Systems (CDSS) to optimize antibiotic prescribing, co-developed with WP5 (Digital health skills and behavioural change) to include behavioral nudges (e.g., real-time alerts for guideline adherence).
- WP3 (Antimicrobial Waste Reduction and Management): A blockchain-based waste tracking module, co-designed with WP5 (Digital health skills and behavioural change), incorporating data analytics tools to enhance transparency and compliance, tailored for pharmacists and healthcare managers.
- WP4 (Patient Empowerment): A mobile app module for patient education on antibiotic misuse, co-created with WP5 (Digital health skills and behavioural change), integrating visual aids and gamified quizzes to promote adherence.

One of the key training modules, created under WP3 (Antimicrobial waste reduction and management), focuses on the use of IT tools by health professionals. Its rationale is based on improving efficiency and quality of care through the integration of technologies and behavior change strategies. The module content is grounded in established theories of behavior change and addresses the day-to-day challenges healthcare professionals face, such as high workloads, risk of clinical errors, and the ongoing need to integrate new technologies into their workflows.

The training module is structured around six thematic areas. The first area introduces emerging technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), Generative AI, and Blockchain, with an emphasis on their applications in healthcare. The second covers digital transformation and the use of

data systems, including interoperability and IT infrastructure. The third focuses on data annotation, text mining, and speech-to-text conversion, which are crucial for handling clinical data efficiently. The fourth addresses privacy and ethical considerations, particularly in the context of GDPR and other health data regulations. The fifth explores how technologies can support behavioral change, offering practical examples of digital interventions. The final module applies these tools to specific healthcare domains, including respiratory diseases, urinary infections, and primary care settings, with use cases tailored for different professional roles.

The learning objectives for the training module were identified in collaboration with Portuguese healthcare entities, including Hospital Santa Maria, Hospital da Luz, and national professional orders. These objectives encompass both knowledge and practical competencies. Participants are expected to understand the fundamental concepts behind emerging technologies, recognize their potential applications, and critically evaluate their impact on healthcare delivery. Participants should acquire practical skills in using data tools and technologies, while also developing ethical awareness and decision-making capabilities. The module also promotes digital literacy tailored to the specific roles of various health professionals and emphasizes the role of technology in enabling behavior change among patients and within clinical teams.

3.3. Training Implementation

Course creation

The course creation involved both platform-based development and local implementation. The Lecturio platform, known for its focus on medical and nursing education, was selected to host the asynchronous modules.

The content was developed by each Work Package and submitted for review and production by the Lecturio team: WP2 (Antimicrobial prescribing optimization) developed 9 training modules focused on clinical content related to the prescription of antibiotics, WP3 (Antimicrobial waste reduction and management) contributed with three modules related to waste management and WP4 (Patient

empowerment) with 3 modules about patient empowerment and communication. This process included multiple rounds of editing and testing, involving feedback loops between content creators and platform designers.

The final course was composed of 15 training modules structured for both independent learning and blended education formats. Portugal and Greece adopted an hybrid format combining the online modules with in-person seminars, while the remaining countries implemented it fully online.

Different learning paths, using the same content creation infrastructure, were developed and tailored to the health sector of each target country. Digital and behavioral change content was integrated into every learning path. These learning paths were adapted to meet national regulatory requirements and the specific needs of healthcare professionals. For example, in Portugal learning paths were defined for four different professional profiles: nurses, doctors, pharmacists and health managers.

Enrolment process and dissemination strategy

The dissemination strategy was structured around identifying relevant stakeholders and a multi-step approach:

- Audience identification: Entities aggregating health professionals, such as professional orders, associations, hospitals, health institutions (e.g., Pharmacy, Nursing, Medical), hospitals/clinics, labs, and waste management companies were identified and contacted.
- Preparation of outreach materials: Standard emails highlighting relevance and including pre-registration forms, as well as visual elements such as posters were developed.
- Contact Management: A dedicated person for confirmations, questions, and participant support was selected

Evaluation

The monitoring and evaluation of the AMR EDUCare training, under WP6, was conducted through a qualitative methodology. Focus groups and semi-structured

interviews in all the project countries were conducted with different health professionals who had completed the training at least three months before the respective focus group/interview. The semi- structured script included questions directly related to the main topics (prescribing, patient communication and waste management) and Key Performance Indicators (KPIs) of the project. For example, one of the questions included was “Did the training help you deepen your knowledge of antimicrobial resistance? If so, can you give an example of what you learned or how the tools you obtained during the training changed your practice?”.

Participants consistently reported that the course was practical and directly relevant to their professional responsibilities. In Portugal, for example, regarding behaviour change and IT tools:

- Visual guides, step-by-step instructions, and brochures were seen as elements that contributed to the improvement of patient communication (e.g., physicians spending more time discussing antibiotic’s correct use with patients; waste managers negotiating new contracts and cleaning guidelines) and communication with colleagues (e.g., discussing protocol changes with management)
- Repetition of key messages across modules and at the end of each section was highlighted as reinforcing confidence and better knowledge acquisition IT tools were considered valuable instruments but rarely applied except through personal use due to constraints related to protocols and contracts

- In Hungary, participants emphasized the need for greater exposure to diagnostic tools, with one manager suggesting that video demonstrations of digital solutions— such as robots mentioned during the training—would help make these innovations more tangible and memorable. Greek doctors highlighted the importance of age- sensitive approaches in course design to better accommodate diverse learning needs. Meanwhile, in Spain, a doctor reported a positive impact from using the rapid testing tool introduced in the course, indicating its potential for immediate clinical application.

4. Recommendations for AMR Education

4.1. Recommendations on Behavioural Change Tools

To promote and ensure sustainable behaviour change among healthcare professionals and patients, AMR education should be based on behaviour change theoric principles and embedded with evidence base tools. We recommend the inclusion of tools aligned with the Behaviour Change Wheel and COM-B model (see deliverable 5.1.).

Tools should be applied across modules and tailored to target different core components of the COM-B model (capability, motivation and opportunity) necessary for a behavior to occur. The following recommendations are proposed to target each of these components:

Targeting Capability

- **Promote capability and awareness:** Provide information and feedback about causes, consequences and alternatives for a problem or problem behavior. It can be implemented in the form of pre- and post-quizzes. Such a tool is aimed at changing the risk perception associated with a given behavior
- **Repetition:** Embed key messages and imagery repeatedly across modules to ensure psychological capability, for example, use familiar images (physical or verbal) to represent a less familiar process
- **Knowledge shaping tools:** Include instructions on how to perform a given behavior, for example in the form of advice.

These behavioural change tools can also be tailored according to different topics and behaviours with the AMR context. Regarding **antimicrobial prescribing**, we recommend the development of printable materials, for example a brochure containing step-by-step instructions and visual guides, namely appealing infographics illustrating step-by-step instructions for various infection prevention behaviours, such as hand hygiene, respiratory etiquette. When it comes to the **communication with and empowerment of patients**, such tools could be

materialised as instructions advising health professionals to use clear and simple language when explaining medical information to patients, avoiding technical jargon, as well as providing visual aids, such as diagrams or infographics, to enhance understanding of the risks associated with self-diagnosis and antibiotic misuse. In terms of **waste education/management**, we recommend the presentation of real-life case studies highlighting the consequences of non-adherence and improper disposal, emphasizing the impact on antimicrobial resistance.

Targeting Motivation

- **Repetition:** Summarize essential and relevant information at end of each section to strengthen beliefs and attitudes about the consequences of a certain behaviour
- **Cultural similarity:** This includes the use of target group features in the source, message and channel. Use stereotypical easily recognised message sources to facilitate the adoption of the desirable behaviour through modelling via identification and as a means of reinforcing (positive) emotions
- **Tailored modules:** Through the creation of different modules targeting different audiences, to ensure a better adherence to the desirable behaviours. This tailored approach can contribute to a reinforcement of positive and/or negative emotions, promote the belief about one's capabilities and contribute to change the belief about the consequences of a certain behaviour
- **Goal setting:** Goal setting consists of setting or agreeing on a goal defined in terms of the behaviour to be achieved, which facilitates acting towards said goals. By helping the person plan what they want to achieve, including a definition of the specific behaviours directed toward the goal, we might also help them see themselves as capable of doing it, thus enhancing their sense of self-efficacy. To enhance both self-efficacy perceptions and acting towards the intended behavioural change, define specific learning objectives and behavioural targets
- **Action preparing and planning:** Present recommendations, with smaller specific steps. Resorting to such tools would help the trainees to see the

change as more feasible and easily attained, by improving their **belief** about their **capabilities** and operationalising their **intentions**

- **Modelling and demonstration:** Incorporate demonstrations by credible role models to reinforce self-efficacy and motivate adoption of best practices.

Targeting both motivation and opportunity

- **Commitment statements:** Encourage health professionals to create personal commitment statements outlining their dedication to responsible prescribing, as well as incentives, i.e., provide small incentives for reaching commitment milestones, further motivating individuals to stay dedicated, as these create an environmental context conducive to the implementation of the desired behavioural change
- **Behavioural nudges**: Nudges make it more likely that an individual will make a particular choice, or behave in a particular way, by altering the environment so that automatic cognitive processes are triggered to favour the desired outcome. For example, recommend the use of visual cues within the consultation room to remind both health professionals and patients of the importance of evidence- based diagnosis and prescription practices, might help both health professionals and patients to decide for a responsible use of antimicrobials as their "default" choice.

4.2. Recommendations on the Introduction of IT tools and Skills

To integrate digital skills and tools, ensuring the ability and of healthcare profession we recommend the following:

Build Digital Competence

- **Introduce emerging technologies early:** Provide structured learning on key IT tools (i.e., AI and Blockchain) as part of antimicrobial stewardship training. This ensures professionals understand their relevance in diagnosis, prevention, and management of infections.
- **Focus on practical applications:** Demonstrate real-world uses of

Electronic Health Records (EHRs), clinical decision support systems (CDSS), and mobile health applications to strengthen decision-making and improve patient outcomes.

- **Highlight ethical and practical limitations:** Integrate ethical considerations and regulatory challenges into training to promote safe and responsible use of digital technologies

Regarding specific topics related to AMR, AI models tailored to AMR contexts contribute to a hands-on approach to AMR training. After finishing the course, healthcare professionals can use these tools for real-world applications, including automating routine tasks in AMR prevention. The following are recommendations tailored to specific AMR areas:

- **Antimicrobial prescription:** Educate professionals on the emerging roles of Artificial Intelligence (AI), the Internet of Things (IoT), and Blockchain technology in the diagnosis, management, and prevention of infections.

  To ensure that these recommendations are actionable, we suggest linking digital skills training directly to behavioural change approaches and professional contexts. For AI, the most effective delivery method is through *simulation-based learning and case studies*, where professionals practice decision-making supported by AI-driven Clinical Decision Support Systems (CDSS) and receive structured feedback. This builds capability and reflective practice (COM-B: capability + motivation). For IoT, short *hands-on workshops* can demonstrate real-time monitoring devices for infection prevention (e.g., smart hand hygiene dispensers), using nudges and environmental cues to reinforce adoption (COM-B: opportunity). For Blockchain, targeted *problem-based learning sessions* for pharmacists and managers can illustrate waste tracking through anonymised data scenarios, highlighting transparency and accountability as motivational levers. Across all technologies, blended delivery (asynchronous modules combined with interactive workshops) has proven most effective for consolidating skills and embedding them into daily practice. By embedding these approaches into professional

training, digital tools are not only introduced but actively used to trigger and sustain desired behaviours in antimicrobial stewardship.

For example, AI can be embedded to provide immediate, detailed insights, such as identifying missing key details in patient summaries, suggesting improvements for clarity and completeness, and assessing diagnostic accuracy against expert standards.

- **Waste management:** Focus on the potential of Blockchain technology to tackle the challenges associated with antibiotic waste management (i.e., transparency, traceability, and accountability) within the healthcare sector.

  To make this recommendation more actionable, Blockchain should be introduced through *scenario-based training modules*. Pharmacists and managers can engage in interactive simulations that map the antibiotic disposal chain, using dashboards that visualise where traceability breaks down and how corrective measures can be applied. This approach strengthens *capability* (digital literacy in managing waste data) while also boosting *motivation* by making the environmental and clinical consequences of improper disposal visible. Incorporating *behavioural nudges* such as automated alerts when waste-handling steps are missed creates an enabling *opportunity* for professionals to adopt safer and more sustainable waste practices.

- **Patient Empowerment:** Train professionals to use AI-powered tools and mobile applications for shared decision-making, medication reminders, self-management support, patient-generated data, peer support.

  To operationalise this recommendation, training should combine role-playing exercises with the use of patient-facing digital tools. For example, clinicians can simulate consultations where mobile apps generate medication reminders or visual explanations of appropriate antibiotic use. This allows professionals to practice simplifying complex information, applying persuasive framing, and building empathy in digital communication. Such delivery methods address capability

(effective use of digital communication tools), opportunity (structured access to patient-support apps), and motivation (greater confidence in influencing patient behaviour). Linking these tools to behavioural principles such as modelling and goal-setting ensures that empowerment goes beyond technology, reinforcing sustainable changes in patient attitudes and practices.

4.3. Recommendations on collaboration regarding AMR education

Establishing collaborations with professional orders is essential to ensure that AMR education has a long-term impact, reaches a wide audience of healthcare professionals, and remains
aligned with evolving clinical priorities. Future collaborations should prioritize:

- **Integration into national continuing education guidelines** so that digital and AMR modules become accredited components of professional development
- **Annual workshops and certification programmes** co-designed with professional orders to ensure relevance and uptake
- **Focus on digital and green skills**, providing healthcare workers with a framework for long-term sustainability

Future programmes should also promote interdisciplinary work as the standard practice since developing AMR training embedded with behavioural change principles and digital tools requires input from a diverse range of knowledge (e.g., behavioural psychologists, computer engineers). Opportunities for interdisciplinary dialogue ensure that training materials are clinically relevant, pedagogically sound, and behaviourally informed.

To strengthen antimicrobial stewardship across Europe, national and European health curricula should embed both **behavioural change strategies** and **digital literacy training** in a systematic and coordinated way.

We recommend:

- **Integration into curricula**: Adopt behavioural science frameworks (COM-B, Behaviour Change Wheel) and align digital competencies with the EU Digital Competence Framework (DigComp 2.1). Training content should be tailored to the specific roles of doctors, nurses, pharmacists, and health managers, and include practical tools such as checklists, quick guides, and infographics to support daily practice.
- **Evaluation and monitoring**: Ensure that most AMR-related modules include digital and behavioural components, with pre- and post-training assessments to measure knowledge, skills, and self-efficacy. Uptake should be monitored by tracking accredited programmes at national and European levels.
- **Feasible implementation**: Build on existing professional development structures and digital learning platforms to deliver training efficiently. Engage professional orders and healthcare institutions in co-developing and endorsing modules. Incorporate case studies and role modelling to facilitate adoption without overburdening professionals.
- **Alignment with priorities**: Ensure training reflects clinical realities such as prescribing, waste management, and patient communication, while remaining consistent with European health priorities on AMR, digital transformation, and patient safety. Promote interdisciplinary collaboration between behavioural scientists, IT experts, and clinicians to strengthen clinical and pedagogical relevance.
- **Clear timelines for action**: Integrate digital and behavioural modules into continuing education programmes by 2026. Launch annual workshops and certification programmes in collaboration with professional bodies starting in 2025. Review and update content every two years to incorporate emerging technologies, evolving clinical needs, and new policy frameworks.

By embedding these elements into health education, Europe can build a workforce that is digitally competent, behaviourally informed, and fully prepared to promote sustainable antimicrobial stewardship.

5. Conclusion

Antimicrobial resistance (AMR) continues to undermine the effectiveness of treatments, threaten patient safety, and strain healthcare systems worldwide. Addressing this challenge requires more than clinical guidelines and technological innovation: it demands a well-prepared workforce that is able to integrate evidence, adapt to new digital environments, and sustain behavioural change in daily practice. This report has sought to demonstrate how a combined approach—bringing together digital literacy and behavioural change strategies—can contribute to this goal by modernising health education at both national and European levels.

The analysis and training implementation carried out within the AMR-EDUcare project revealed several important insights. First, education that focuses exclusively on knowledge transfer is insufficient. Professionals face barriers such as time constraints, entrenched routines, institutional pressures, and misperceptions about antibiotics. Embedding behavioural change strategies is therefore essential. By using models such as COM-B and the Behaviour Change Wheel, training can directly target capability, motivation, and opportunity. Practical applications include tools like visual guides, goal-setting exercises, feedback mechanisms, and behavioural nudges—each designed to make best practices easier to adopt and sustain.

Second, the growing role of technology in healthcare requires systematic attention to digital literacy. Professionals must be trained not only in the technical use of electronic health records, decision support systems, and mobile health applications, but also in understanding their ethical, regulatory, and clinical implications. Furthermore, exposure to emerging technologies—such as artificial intelligence, the Internet of Things, and blockchain—can prepare professionals to anticipate future developments and integrate them responsibly into antimicrobial stewardship. By aligning with the EU Digital Competence Framework (DigComp 2.1), digital skills training can provide a common foundation across Europe while still allowing for national adaptation.

Third, the effectiveness of both digital and behavioural components depends on structural integration. Training should be embedded in accredited continuing education programmes, ensuring that modules become part of professional development pathways rather than isolated initiatives. Interdisciplinary collaboration—bringing together behavioural scientists, IT specialists, educators, and clinicians—further enhances the quality and relevance of content. In addition, modular design and role-specific pathways enable training to respond to the diverse needs of doctors, nurses, pharmacists, and health managers, while maintaining coherence across Europe.

Finally, the project highlights the importance of sustainability and long-term impact. Curricula must be reviewed regularly to remain aligned with new technologies, evolving clinical priorities, and emerging evidence. Partnerships with professional orders and healthcare institutions are crucial for dissemination, legitimacy, and uptake. Evaluation mechanisms, including pre- and post-training assessments and long-term monitoring, can ensure accountability and provide evidence of impact.

Key Takeaways

1. Beyond Knowledge

Knowledge transfer alone is insufficient; behavioural barriers exist (time, routines, institutional pressures, misconceptions).

Behaviour change strategies (COM-B, Behaviour Change Wheel) with practical tools (visual guides, goal-setting, feedback, nudges) are essential.

2. Digital Literacy

Training in EHRs, decision-support systems, health apps, and emerging tech (AI, IoT, blockchain) is crucial.

Aligns with **EU Digital Competence Framework (DigComp 2.1)** for a common, adaptable foundation.

3. Structural Integration

Embed training in accredited continuing education.

Interdisciplinary collaboration and modular, role-specific pathways enhance relevance and coherence.

4. Sustainability & Impact

Regular curriculum updates, partnerships with professional bodies, and ongoing evaluation ensure long-term effectiveness.

5. Dual Strategy

Digital skills provide tools; behavioural change ensures they are used effectively.

Integrated approach strengthens healthcare resilience and responsible antimicrobial use.

In conclusion, the findings of this report reinforce the need for a dual strategy: digital literacy provides the tools, while behavioural change provides the pathways to ensure those tools are used effectively. By embedding both dimensions into health curricula, Europe can cultivate a workforce that is not only technically competent but also behaviourally equipped to translate knowledge into sustainable practice. This integrated approach represents a critical step towards reducing inappropriate antimicrobial use, protecting the effectiveness of existing treatments, and strengthening the resilience of healthcare systems in the face of AMR.

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