HEALTH WITHOUT BORDERS
ACADEMY HUB

Global Alliance for Infections in Surgery

RETHINKING HEALTH BEYOND BORDERS

Science, solidarity and shared responsibility in a changing world



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This publication combines scientific evidence, established knowledge, and the author's personal reflections and interpretations on global health, scientific integrity, education, international co-operation, and related challenges.

This publication is not a comprehensive global health textbook or a substitute for the work of specialists in that discipline. Its purpose is to offer the author's interpretation of how the understanding of health should evolve in response to contemporary scientific, social, environmental and ethical challenges.

Some sections express the author's personal perspectives, which are intended to encourage critical thinking, constructive dialogue, and open scientific discussion. Readers may agree or disagree with these considerations, which should not necessarily be interpreted as universally accepted positions or as representing the views of any institution, organization, or scientific society with which the author is affiliated.

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This publication is intended for scientific discussion and general educational purposes. It does not provide individual medical advice, clinical practice guidelines, or a substitute for professional judgment. Recommendations and interpretations should be considered in light of current evidence, local circumstances, and applicable professional standards.

Declaration on the Use of Artificial Intelligence

Artificial intelligence tools, specifically ChatGPT (OpenAI), supported the linguistic editing and refinement of this manuscript, including improvements in grammar, clarity, readability, stylistic consistency, and organisation.

All AI-assisted revisions were reviewed and validated by the author. The scientific content, personal reflections, interpretations, and conclusions remain entirely the responsibility of the author, who assumes full responsibility for the accuracy, integrity, and final content of this publication.

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Preface

Global health is facing an era of unprecedented complexity. Infectious disease outbreaks, shortages of essential medical resources, climate change, extreme weather events, armed conflicts, and population displacement increasingly interact, creating challenges that extend far beyond national borders. Beyond their immediate consequences, these crises expose persistent inequalities in access to healthcare, scientific knowledge, technological innovation, adequate nutrition, and essential resources. They also remind us that health cannot be understood solely as the absence of disease, but must be considered within the broader social, environmental, economic, and ethical conditions that shape human well-being.

In an increasingly interconnected world, health challenges rarely remain confined to individual countries. An infectious disease may emerge in one region, be investigated by researchers in another, and require diagnostic technologies, medicines, or vaccines developed and manufactured elsewhere. Environmental degradation, food insecurity, antimicrobial resistance, and humanitarian emergencies similarly demonstrate how closely human health is connected to decisions and events occurring across geographical boundaries. Addressing these challenges requires not only scientific progress, but also sustained international cooperation, equitable access to innovation, and resilient healthcare systems capable of responding to both immediate emergencies and long-term needs.

International cooperation, however, should not begin only when a crisis occurs. It must be cultivated through continuous scientific exchange, education, mutual respect, and the development of lasting professional and institutional relationships. Sharing knowledge across borders is not simply an expression of solidarity; it is an essential means of strengthening collective preparedness, improving healthcare delivery, and reducing inequalities.

A borderless vision of health does not diminish national responsibilities, local priorities, or the importance of context-specific solutions. Rather, it recognizes that healthcare systems become stronger when they can learn from one another under conditions of fairness and reciprocity. Scientific knowledge should not be regarded as flowing exclusively from wealthier countries to less-resourced settings. Experience gained in resource-limited environments, including innovative approaches to care, community engagement, adaptation, and the responsible use of available resources, represents valuable expertise from which the entire international community can learn.

This book is not intended to be a textbook of Global Health, nor does it claim to offer a comprehensive or authoritative account of a complex scientific discipline. Global Health encompasses multiple areas of specialized knowledge, including public health, epidemiology, health systems, health economics, health policy, environmental sciences, and social sciences. The contributions

of professionals and researchers dedicated to these fields are indispensable and deserve full recognition.

The perspective offered in these pages is deliberately different. Drawing on clinical experience, scientific literature, and years of international professional collaboration, this book presents a personal, multidisciplinary, and scientifically informed reflection on how the concept of health should be understood and interpreted in the contemporary world. Its purpose is not to replace specialist perspectives, formulate definitive theories, or provide exhaustive scientific guidance, but to stimulate reflection on the profound transformations that are reshaping the relationship between health, science, society, and our shared future.

From this perspective, health extends beyond the prevention, diagnosis, and treatment of disease. It encompasses equitable access to healthcare, education, scientific knowledge, adequate and safe nutrition, food security, environmental sustainability, ethical leadership, social responsibility, and the capacity of individuals and communities to live with dignity. These dimensions are closely interconnected and cannot be effectively addressed through isolated scientific disciplines or fragmented institutional responses.

The reflections developed throughout this book combine established scientific knowledge, selected scientific literature, professional experience, and personal interpretation. They are offered as a contribution to scientific and cultural dialogue rather than as a clinical guideline, systematic review, or exhaustive evaluation of the available evidence. Particular attention is given to maintaining a clear distinction between conclusions supported by scientific evidence and broader interpretations intended to encourage independent thinking and constructive discussion. This approach reflects the fundamental conviction that scientific progress depends not only on the generation of new knowledge, but also on the integrity, independence, openness, and intellectual honesty of the scientific community. Evidence must remain the foundation of informed healthcare decisions, while legitimate scientific disagreement, supported by rigorous methods and verifiable data, should be recognized as an essential component of scientific advancement.

Protecting scientific independence also requires the courage to resist inappropriate political, economic, commercial, and ideological interference. At the same time, intellectual freedom carries a responsibility to distinguish evidence-based criticism from unsupported assertions and deliberate misinformation. Scientific credibility is strengthened not by the absence of disagreement, but by transparency, methodological rigor, accountability, and the willingness to revise established positions when reliable new evidence becomes available.

Another central theme of this book is the responsibility to make scientific knowledge accessible and useful. Scientific discoveries achieve their greatest value when they can be translated into practical decisions, effective interventions, and measurable improvements in people's lives. The

generation of evidence is therefore only one part of scientific responsibility; its dissemination, interpretation, adaptation, and implementation are equally important.

Education and knowledge sharing play a particularly important role in this process. They create opportunities for healthcare professionals, researchers, institutions, and communities to develop their capabilities, exchange experiences, and contribute to solutions adapted to different social, cultural, and economic contexts. Meaningful international collaboration should be based on mutual respect, recognition of local expertise, and the understanding that every participant can contribute valuable knowledge.

The experience of working with colleagues from different countries and healthcare environments has reinforced my belief that the most productive scientific relationships are built not simply through formal agreements or institutional structures, but through trust, generosity, intellectual humility, and a shared commitment to improving human health. Such relationships demonstrate that geographical distance, cultural differences, and unequal resources need not prevent meaningful scientific cooperation.

Importantly, the idea of *Health Beyond Borders* is not that borders cease to exist, but that they should not become barriers to knowledge, solidarity, scientific dialogue, or opportunities for better health. It is an invitation to interpret health through a broader perspective, recognizing the interdependence of human well-being, social justice, environmental responsibility, scientific integrity, and international cooperation.

This book does not seek to provide definitive answers to the many challenges facing contemporary health systems. Instead, it aims to encourage informed reflection, stimulate constructive dialogue, and promote a greater awareness of the responsibilities shared by healthcare professionals, scientists, institutions, policymakers, and society as a whole.

Above all, it is inspired by the conviction that science achieves its highest purpose when knowledge is shared, human dignity is respected, and scientific progress contributes to the common good. In a world increasingly shaped by uncertainty, fragmentation, and interconnected crises, building a healthier future will require more than technological innovation or scientific discoveries alone. It will require independence of thought, ethical responsibility, mutual trust, solidarity, and the willingness to act together.

Health may be shaped by local realities, but the responsibility to protect and improve it belongs to all of us.

Massimo Sartelli

1

Why global health needs a borderless approach

Interdependence is a working condition, not a slogan

Global health interdependence should not be understood exclusively as a relationship in which better-resourced countries provide financial support, technologies, and scientific expertise to countries with fewer resources. It must also be recognized as an opportunity for wealthier healthcare systems to learn from the experience, practical knowledge, and organizational methods developed in resource-limited settings. Countries facing persistent financial constraints, shortages of healthcare professionals, limited technological infrastructure, and restricted access to diagnostic and therapeutic resources have often been required to develop pragmatic approaches to healthcare delivery based on careful prioritization, efficient organization, adaptability, and the rational use of available resources.

These experiences represent an important source of knowledge that deserves greater recognition within international scientific cooperation. Working with fewer resources does not necessarily mean working without a method or accepting lower standards of care. On the contrary, difficult operating conditions can encourage the development of structured methodologies that distinguish essential interventions from those of limited value, identify achievable priorities, simplify complex procedures without compromising their fundamental objectives, and organize healthcare activities around what is clinically necessary and practically sustainable. Professionals working in these environments may develop considerable expertise in problem-solving, teamwork, clinical decision-making, and the adaptation of evidence-based interventions to real-world constraints. Their experience can help demonstrate that effective healthcare depends not only on the quantity of resources available, but also on the quality of decisions, the organization of services, the competence of professionals, and the ability to use resources appropriately.

This perspective is increasingly relevant to better-resourced healthcare systems, which are themselves facing rising healthcare costs, workforce shortages, ageing populations, increasing demand for services, and growing pressure to improve environmental and economic sustainability. Approaches developed in resource-limited settings may offer valuable lessons in reducing unnecessary procedures, improving resource allocation, strengthening essential services, and developing simpler, more accessible, and resilient models of healthcare delivery. Such learning should not involve transferring solutions mechanically from one context to another, but rather

understanding the underlying principles and methodologies that make them effective and determining how they can be adapted to different healthcare environments.

At the same time, recognizing the innovative capacity of resource-limited countries must never be used to justify chronic underfunding, inadequate infrastructure, or inequalities in access to essential healthcare. The ability to achieve meaningful results despite limited resources is a demonstration of professional competence and organizational resilience, not evidence that additional investment is unnecessary. Resource efficiency and equitable resource provision are complementary objectives. Every healthcare system should have access to the essential conditions required to deliver safe and effective care, while also learning how to use those resources responsibly.

A truly equitable model of global health cooperation must therefore replace the traditional distinction between countries that teach and countries that learn with a framework of mutual contribution and shared knowledge. Better-resourced systems may offer advanced technologies, research infrastructure, and specialized expertise, while less-resourced systems may contribute valuable methodologies for prioritization, adaptability, appropriate resource utilization, and sustainable service delivery. Both forms of knowledge are essential. Scientific excellence should not be measured exclusively by technological sophistication or financial investment, but also by the capacity to transform available knowledge and resources into meaningful improvements in population health.

The central lesson of global health interdependence is that every country has something to learn and something to teach. Countries with fewer resources can help the rest of the world understand not simply how to do more with less, but how to work more intelligently, methodically, and sustainably, without losing sight of quality, patient safety, and equity. Genuine international solidarity emerges when this reciprocal exchange is recognized as a fundamental component of scientific progress and when all partners are valued not only for the resources they possess, but also for the knowledge, experience, and solutions they can contribute.

Figure 1 illustrates the importance of bidirectional knowledge exchange between health systems with different levels of resources. Better-resourced settings can contribute advanced research infrastructure, technologies, and specialist training, while resource-constrained settings can provide valuable experience in prioritizing essential interventions, adapting clinical practices to local limitations, and delivering effective care with fewer resources.

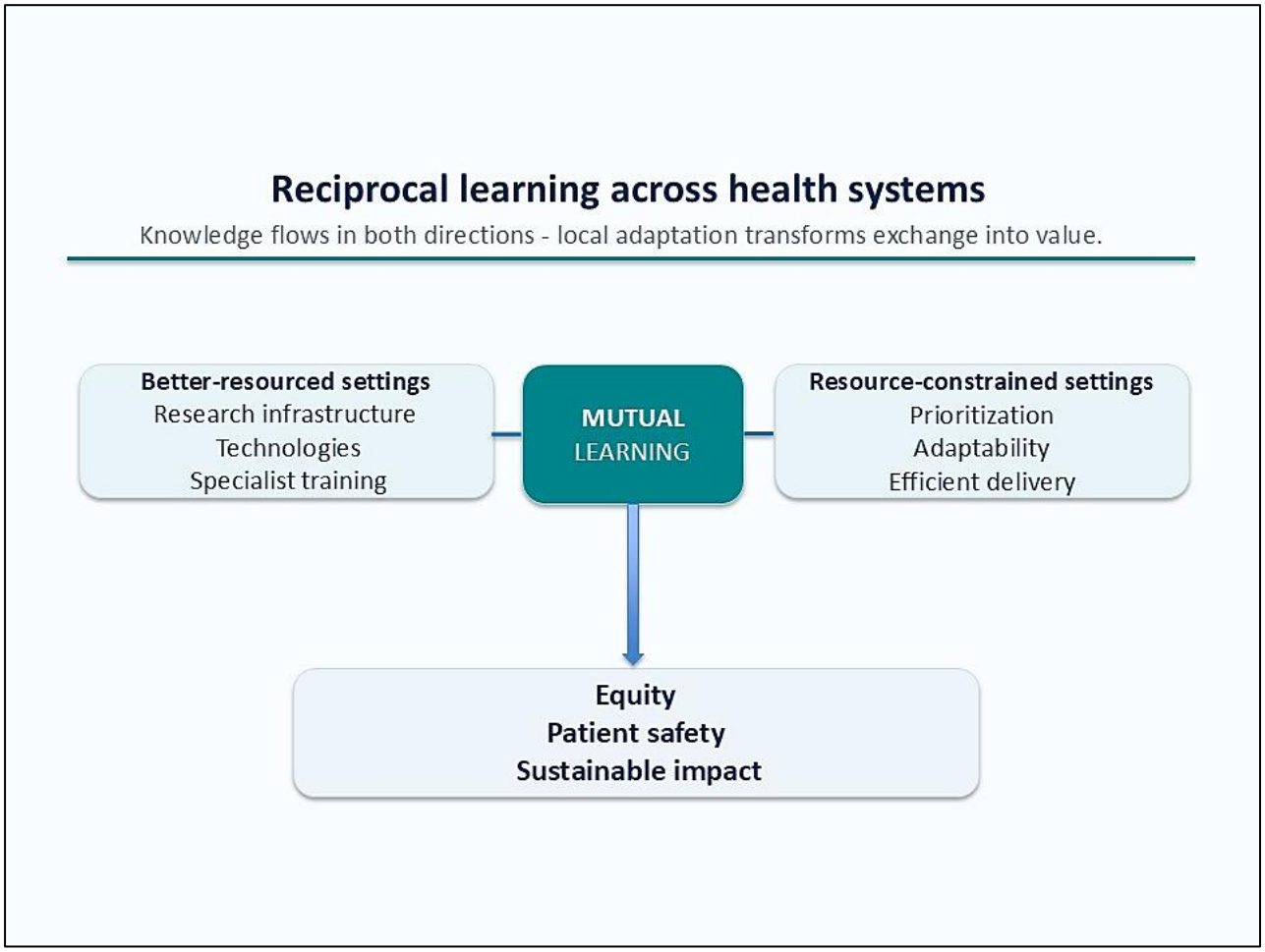


Figure 1. Reciprocal learning across health systems.

Social determinants of health: equity begins beyond healthcare

The conditions in which people are born, grow, learn, work and age influence health long before a clinical encounter. Household income, education, adequate housing, safe employment, gender-related inequalities, disability, exposure to pollution and access to political representation shape both the probability of becoming ill and the capacity to obtain timely care. The same disease can therefore have markedly different consequences depending on the social environment in which it develops. The World Health Organization's 2025 report on the social determinants of health equity emphasizes that avoidable differences in health are rooted in unequal distributions of opportunities, resources and power. [1]

A borderless approach must recognize that hospitals cannot, by themselves, compensate for unsafe living conditions or persistent exclusion. Health ministries need to work with institutions responsible for education, labour, housing, social protection, transport and environmental policy.

For example, improving access to insulin is necessary for diabetes care, but the benefits may be limited when a patient cannot afford nutritious food, transport to follow-up visits or safe storage for medicines. Effective policy connects clinical services with the everyday realities that determine whether treatment can succeed.

These determinants operate at several interconnected levels. Structural determinants include how political and economic institutions distribute income, opportunities, public services and decision-making power. More immediate determinants include the quality of housing, access to clean water and sanitation, nutrition, job security, social relationships and exposure to environmental hazards. These conditions interact throughout life. Disadvantage in early childhood may affect educational achievement, employment prospects and health decades later. Consequently, reducing health inequalities requires an approach that addresses both immediate needs and the underlying circumstances that repeatedly generate vulnerability.

Poverty influences health through more than the inability to purchase medical treatment. Families facing financial insecurity may postpone preventive visits, live in overcrowded or poorly insulated housing, experience food insecurity, or accept unsafe working conditions. Conversely, illness can reduce household income through lost employment and direct or indirect healthcare costs. This creates a reinforcing cycle in which social disadvantage increases the risk of disease and disease deepens disadvantage. Social protection, affordable essential services and financial protection within universal health coverage can help interrupt this cycle, particularly for households experiencing multiple forms of exclusion.

Education is both a determinant of health and an instrument for reducing inequalities. Access to good-quality schooling influences employment opportunities, understanding of health information and the ability to navigate healthcare systems. Health literacy, however, should not be treated solely as an individual responsibility. Health institutions must make information understandable, culturally appropriate and accessible to people with different languages, disabilities and levels of literacy. A system that requires patients to interpret complicated instructions, travel repeatedly for appointments or use digital services without assistance may unintentionally widen the inequalities it is intended to reduce.

Working and living environments also have direct clinical consequences. Occupational exposure to hazardous substances, excessive heat, injuries, chronic stress and insecure employment may increase health risks, while inadequate housing can aggravate respiratory disease, infectious transmission and mental distress. Urban design influences physical activity, traffic-related injuries, air pollution and access to essential services. Rural populations may experience different barriers, including distance from healthcare facilities, limited public transport and insufficient

digital connectivity. Strategies to improve health must therefore be adapted to place rather than assuming that national-level solutions reach every community equally.

Discrimination and unequal social power can further shape who is heard, who receives timely care and whose needs influence public decisions. Gender, disability, migration status, age and socioeconomic position may intersect, creating barriers that are not visible when each factor is examined separately. Responses should avoid stereotypes and be guided by local evidence and meaningful consultation. Involving patients, community representatives and frontline professionals in programme design can reveal practical obstacles overlooked by central authorities, such as inaccessible buildings, administrative requirements, language barriers or fear of losing income when seeking care.

The commercial and environmental contexts of health deserve particular attention. The availability, affordability and marketing of unhealthy products can influence diets and long-term disease risks, while air pollution, climate-related hazards and inadequate water or sanitation disproportionately affect people with fewer means to protect themselves. Public health policies should therefore assess how decisions in agriculture, energy, transport, labour markets and urban planning influence health. Such policies are more effective when they combine evidence, transparent regulation and social safeguards, rather than placing the entire burden of prevention on individual behaviour.

Translating this understanding into policy requires a practical “health in all policies” approach. When a municipality designs a transport system, for example, decision-makers can consider access to clinics, air quality, road safety and the needs of people with reduced mobility. When governments introduce climate adaptation or housing programmes, they can assess whether benefits reach those most exposed to risk. Healthcare organizations can contribute by identifying patterns of avoidable harm, referring patients to appropriate community services and sharing aggregated evidence with social and public-health institutions. Nevertheless, hospitals should not be expected to solve structural problems without coordinated public action and adequate resources.

Measurement is essential, but averages can conceal the very inequalities that policies seek to address. Monitoring should combine population outcomes with indicators of access, affordability, service quality and social conditions, disaggregated where lawful and appropriate. Quantitative evidence should be complemented by community experience, because barriers that appear minor to administrators can determine whether an intervention is actually usable. Evaluation should ask not only whether population health improved, but also whether the gap between more advantaged and disadvantaged groups narrowed, whether unintended harms emerged and whether gains can be sustained over time.

Importantly, action on the social determinants of health is not separate from medical care: it makes effective care possible. Clinical services remain indispensable for diagnosing and treating illness, but their impact is limited when patients return to circumstances that repeatedly undermine recovery. A fair global health strategy must therefore combine accessible, high-quality healthcare with investment in education, decent work, adequate housing, social protection, environmental safety and community participation. Health equity begins before the patient enters the hospital and continues long after the clinical encounter.

Equity also requires measuring differences within countries rather than relying on national averages. Outcomes should be examined, where appropriate and ethically justified, by geography, income, gender, age, disability and other relevant dimensions of disadvantage. Communities affected by an intervention should participate in identifying problems and assessing whether solutions are acceptable. The objective is not to promise identical outcomes for everyone, but to reduce preventable and unjust barriers to a healthy life.

From principles to durable international cooperation

Public statements can establish norms and mobilize attention, but their impact fades without sustained institutional commitment. Sustainable international cooperation requires more than shared scientific interests, formal agreements, or occasional opportunities for professional interaction. It depends on the willingness of institutions to allocate time, authority, human resources, and organizational support to the practical implementation of common objectives. International networks become meaningful when collaboration is integrated into institutional activities rather than treated as an additional responsibility dependent on the personal commitment of a limited number of individuals. This requires a long-term perspective in which cooperation is understood as a continuous process of learning, adaptation, and shared responsibility.

A sustainable network is built through repeated interaction and the progressive development of mutual trust. Its strength depends not simply on the number of participating institutions or countries, but on the quality and continuity of the relationships established among them. Jointly identifying relevant health challenges, exchanging professional experiences, developing shared educational materials, providing mentoring opportunities, and periodically evaluating progress can transform occasional collaboration into a lasting framework for collective action. These activities also create opportunities for healthcare professionals working outside major academic centres to participate actively in international scientific and educational initiatives.

Long-term cooperation requires stable institutional relationships that extend beyond individual projects, funding cycles, or changes in leadership. Partnerships that rely primarily on the motivation, professional influence, or personal relationships of a single individual may achieve important

results but remain vulnerable when that person changes responsibilities, retires, or leaves the organization. Continuity therefore requires the progressive transfer of responsibilities from individuals to institutions, supported by transparent governance, clearly defined roles, shared objectives, and mechanisms that allow activities to continue despite organizational transitions.

Institutional commitment should also be reflected in practical arrangements. Collaboration requires protected time for educational and scientific activities, access to appropriate communication tools, administrative support, and opportunities for participants to contribute to decisions. Without these conditions, international cooperation may remain largely symbolic, generating visibility and goodwill without producing sustainable improvements in professional practice. Even relatively modest institutional investments can have considerable value when they support regular communication, accessible educational resources, and the continuity of shared programmes.

An important element of sustainability is the development of shared scientific and educational resources. Educational materials, clinical experiences, implementation tools, and training activities developed collaboratively can remain available to participating institutions beyond the duration of individual initiatives. Open-access resources, multilingual educational content, virtual learning environments, and adaptable training programmes can facilitate wider participation, particularly among professionals who face geographical, financial, or institutional barriers to attending international meetings.

However, accessibility should not be understood exclusively in technological terms. Educational opportunities must also consider differences in language, professional background, available infrastructure, working conditions, and local healthcare priorities. A programme that is easily accessible to professionals in a well-resourced academic institution may remain difficult to use in settings with limited internet connectivity, insufficient staffing, or inadequate opportunities for protected learning time. Sustainable educational cooperation therefore requires flexible approaches that respond to the practical circumstances of participants and avoid reproducing existing inequalities in access to scientific knowledge.

The development of international networks should also encourage reciprocal exchanges rather than one-directional transfers of expertise. Every healthcare setting possesses experiences that can contribute to collective learning. Institutions with advanced research infrastructure may provide access to specialized knowledge, educational platforms, and methodological support, while professionals working in resource-constrained environments may offer valuable insights into adaptability, prioritization, and the implementation of essential interventions under difficult conditions. Recognizing these different forms of expertise strengthens mutual respect and helps ensure that collaboration remains relevant to the needs of all participants.

The involvement of younger healthcare professionals is particularly important for ensuring the continuity and future development of international partnerships. Early-career clinicians, researchers, nurses, public health professionals, and other members of the healthcare workforce should not be regarded exclusively as recipients of educational activities, but as active contributors to scientific discussion, programme development, and institutional decision-making. Their participation can introduce new perspectives, strengthen professional networks, and support the progressive transfer of knowledge and leadership between generations.

Mentoring across career stages can play a central role in this process. Experienced professionals can support younger colleagues by sharing scientific expertise, practical experience, and an understanding of the organizational challenges involved in international cooperation. At the same time, younger professionals can contribute emerging competencies, familiarity with digital technologies, and new approaches to communication and collaborative learning. When mentoring is structured around mutual exchange rather than rigid professional hierarchies, it can become a powerful mechanism for strengthening both individual competencies and institutional capacity.

Leadership development should therefore be considered an essential component of sustainable cooperation. International networks need opportunities for younger participants to assume increasing responsibilities in educational activities, research coordination, programme evaluation, and strategic planning. Creating inclusive governance structures, encouraging shared leadership, and ensuring that responsibilities can be transferred over time reduces institutional dependence on individual personalities and contributes to the resilience of collaborative initiatives.

These principles are particularly relevant for international scientific societies, professional associations, academic institutions, and educational networks. Conferences, scientific meetings, and high-profile international initiatives can generate enthusiasm, visibility, and opportunities for new partnerships. However, their long-term value depends on what happens after the event has concluded. The relationships established during a conference become more meaningful when they lead to continuing educational activities, collaborative research, shared implementation projects, mentoring relationships, or practical improvements in healthcare delivery.

Regular interaction is therefore essential. Periodic scientific discussions, collaborative workshops, online educational sessions, shared projects, and structured opportunities for feedback can maintain engagement between major international events. These activities need not always be complex or resource-intensive. Their value lies in creating continuity, allowing professionals to exchange experiences, discuss emerging challenges, and progressively develop approaches that respond to changing healthcare needs.

The identification of common priorities should remain a collaborative process. International programmes are more likely to achieve meaningful results when the problems addressed are

selected through dialogue among participating institutions rather than determined exclusively by the most influential or best-resourced partners. This requires listening to local professionals, recognizing differences in epidemiological patterns and healthcare organization, and allowing participants to identify the challenges they consider most relevant to their patients and communities. Such an approach also improves the practical relevance of scientific education. The dissemination of evidence is necessary, but knowledge alone does not guarantee changes in professional behaviour or healthcare outcomes. Educational initiatives should help participants understand how scientific findings can be interpreted, adapted, and implemented within their own institutions. This may involve identifying local barriers, assessing available resources, discussing feasible interventions, and developing practical strategies that can be incorporated into everyday clinical activities.

A borderless approach to global health therefore connects scientific knowledge with the realities of professional practice. Accessible education creates opportunities for dialogue among healthcare workers operating in different environments, while reciprocal exchanges help identify which approaches are relevant, feasible, and sustainable in specific contexts. Shared learning can strengthen local capacity, support more informed clinical and organizational decisions, and encourage improvements that can be evaluated over time.

Implementation should be understood as an ongoing process rather than the final stage of knowledge dissemination. Scientific evidence must be translated into interventions that healthcare professionals can realistically adopt and maintain. This requires attention to organizational culture, leadership support, workforce competencies, available infrastructure, and the capacity of institutions to monitor progress. International collaboration can support this process by providing educational tools, methodological guidance, opportunities for comparison, and access to professional networks capable of discussing common implementation challenges.

Evaluation is equally important for maintaining the credibility and effectiveness of international partnerships. The success of a collaborative network should not be measured solely by the number of countries represented, meetings organized, publications produced, or participants enrolled in educational activities. These indicators may reflect engagement and scientific productivity, but they do not necessarily demonstrate whether cooperation has strengthened healthcare systems or improved professional practice.

More meaningful evaluation should consider the extent to which participants have acquired useful competencies, institutions have developed sustainable capacity, and shared initiatives have contributed to identifiable improvements in healthcare delivery. It should also examine whether educational opportunities reach professionals working outside major academic centres, whether

institutions with fewer resources participate meaningfully in decision-making, and whether the benefits of collaboration are distributed equitably.

Importantly, evaluation should involve the professionals and institutions participating in the network. The definition of success should not be imposed exclusively by external coordinators, funding organizations, or academic leaders. Local participants should contribute to selecting priorities, identifying feasible indicators, interpreting results, and determining which activities should be maintained, modified, or discontinued. Such participation strengthens institutional ownership and helps ensure that international cooperation remains responsive to actual healthcare needs.

Sustainable networks must also be capable of adapting to changing circumstances. Healthcare priorities evolve, scientific evidence develops, professional roles change, and institutions may encounter new economic, environmental, or organizational pressures. Partnerships that remain excessively dependent on fixed programmes or predefined objectives may become less relevant over time. By contrast, networks that encourage open communication, constructive feedback, and periodic reassessment can respond more effectively to emerging challenges while preserving their underlying commitments.

Flexibility should nevertheless be balanced with continuity. Constantly replacing existing programmes with new initiatives can fragment resources, weaken institutional memory, and reduce opportunities to evaluate long-term results. Sustainable cooperation requires the ability to distinguish between activities that should evolve, those that should be expanded, and those that remain valuable precisely because they provide stable opportunities for education and professional exchange.

This balance between innovation and continuity is particularly important when resources are limited. International collaboration does not always require the creation of new organizations, expensive infrastructures, or large-scale programmes. Existing professional networks, scientific societies, universities, hospitals, and public health institutions can often strengthen their impact by coordinating activities, sharing educational resources, and establishing common objectives. Greater integration among existing initiatives may reduce duplication, improve the use of available resources, and create more consistent opportunities for participation.

The human dimension of cooperation should not be underestimated. Scientific networks are sustained by institutions, but they are experienced through relationships among professionals. Trust, mutual respect, willingness to listen, recognition of different perspectives, and a shared commitment to improving healthcare create the foundations upon which durable collaboration can develop. These qualities cannot replace institutional structures, but they give those structures meaning and help transform formal partnerships into communities of professional learning.

Ultimately, sustainable international cooperation depends on the ability to connect long-term institutional commitment with everyday professional engagement. Shared objectives must be supported by practical resources, educational opportunities must translate into locally relevant actions, and scientific collaboration must create space for equitable participation across countries, institutions, disciplines, and career stages.

The objective is not simply to establish larger international networks, but to develop networks that remain active, inclusive, useful, and capable of generating measurable benefits over time. Their success depends on whether they strengthen professional competencies, support local leadership, facilitate the responsible application of scientific evidence, and create opportunities for continuous improvement.

A truly borderless approach to global health is therefore not defined by the absence of geographical boundaries alone, but by the ability to build lasting relationships that connect knowledge, institutions, and people through shared responsibility.

When international cooperation is grounded in mutual learning, equitable participation, institutional continuity, and practical implementation, it can move beyond individual initiatives and become a sustainable mechanism for improving healthcare. Its greatest value lies not in the visibility of international collaboration, but in the enduring capacity it creates: professionals better prepared to respond to health challenges, institutions better equipped to translate evidence into practice, and healthcare systems progressively strengthened through collective knowledge and action.

Key messages

- Health threats cross borders, but effective responses depend on strong local systems and sustained international cooperation.
- Genuine partnerships share decision-making, expertise, recognition and benefits, rather than transferring knowledge in only one direction.
- Equity means adapting support to actual needs without lowering standards of care or scientific quality.
- Judge collaboration by durable local capabilities and better health outcomes, not visibility or the number of events.

2

Trust, scientific integrity and public communication

The social foundations of trustworthy evidence

Public confidence in health advice cannot be imposed or taken for granted; it must be earned and sustained through transparency, scientific integrity, institutional accountability and consistent communication. Trust develops when scientific institutions clearly explain what is known, distinguish established evidence from preliminary findings or interpretation, acknowledge uncertainty and communicate the reasoning behind their recommendations. During public health emergencies, when knowledge evolves rapidly and decisions must often be made under conditions of incomplete evidence, changes in guidance may reflect scientific progress rather than institutional failure. Explaining why recommendations have changed, what new evidence has emerged and how that evidence has influenced decision-making is essential to maintaining credibility. Presenting scientific recommendations as definitive and immutable may provide temporary reassurance, but it risks undermining public confidence when subsequent revisions become necessary.

Effective scientific communication should therefore emphasize that uncertainty is not a weakness of science but an inherent component of the scientific process. Scientific knowledge advances through observation, experimentation, critical appraisal, independent verification and the continuous reassessment of existing conclusions. Recognizing uncertainty does not mean questioning the reliability of all scientific findings. Rather, it requires communicating the different degrees of confidence associated with available evidence and distinguishing well-established conclusions from areas in which further investigation is needed. Institutions that acknowledge limitations, explain disagreements and correct errors openly demonstrate a commitment to truth that is ultimately more credible than an appearance of absolute certainty. Public trust should consequently be understood as an ongoing relationship between scientific institutions, healthcare professionals, policymakers and communities, rather than the result of isolated communication campaigns.

Trust also depends on the conditions under which scientific evidence is produced, evaluated and disseminated. Selective publication, undisclosed financial or institutional conflicts of interest, restricted access to research data, inadequate methodological standards and pressure to produce positive or commercially attractive results can distort the scientific record and weaken confidence in research findings. The reproducibility debate has highlighted the importance of transparent methodologies, open scientific practices, independent verification and research environments that reward methodological rigor, reliability and meaningful contributions to knowledge rather

than novelty alone [2]. Strengthening scientific integrity therefore requires not only individual ethical responsibility but also institutional mechanisms that promote transparency, accountability, methodological quality and the correction of the scientific record when necessary.

Protecting scientific credibility also requires a clear distinction between legitimate scientific dissent and the deliberate distortion, manipulation or rejection of established evidence. Scientific progress depends on the freedom to question prevailing interpretations, challenge hypotheses and critically examine existing recommendations. Reasoned disagreement, grounded in sound methodology, verifiable observations and coherent scientific arguments, must be respected and protected, including when it challenges widely accepted positions. Scientific consensus should never become an instrument for suppressing justified criticism or discouraging independent investigation. At the same time, freedom of scientific debate does not imply that all claims possess equal validity. Evidence cannot be reduced to personal opinion, and unsupported assertions, ideological positions or selectively presented information should not be given the same credibility as conclusions supported by rigorous and reproducible research.

This distinction is particularly important in an information environment increasingly shaped by social media, rapid dissemination of unverified claims and the deliberate exploitation of scientific uncertainty. Public discussion frequently places evidence-based recommendations alongside misleading interpretations, conspiracy narratives or statements presented without adequate scientific support. Such false equivalence can create confusion, weaken adherence to effective public health measures and undermine confidence in scientific institutions. Addressing these challenges requires more than correcting misinformation after it has spread. It demands sustained investment in scientific literacy, accessible communication, independent journalism and educational initiatives that enable individuals to evaluate the credibility of sources, understand the principles of scientific reasoning and recognize the difference between genuine uncertainty and manufactured doubt.

The independence of science is equally fundamental. Scientific institutions, universities, professional societies and public health authorities must be protected from political, ideological, economic and commercial pressures that seek to influence research priorities, suppress inconvenient findings or alter the interpretation of evidence. Although scientific knowledge necessarily informs public policy, the evaluation of scientific evidence must remain distinct from political preferences and institutional interests. Policymakers may legitimately consider economic, ethical and social factors when making decisions, but these considerations should be communicated transparently rather than presented as scientific conclusions. Maintaining this distinction helps preserve both the integrity of scientific advice and the accountability of democratic decision-making.

Importantly, defending science does not mean defending every scientific institution, recommendation or prevailing interpretation from criticism. It means defending the principles and methods that make scientific knowledge reliable, open to scrutiny and capable of self-correction. A strong scientific community must remain pluralistic in its perspectives while united in its commitment to evidence, methodological rigor, intellectual honesty and professional responsibility. Legitimate disagreement should stimulate better research and more robust conclusions, not fragmentation or hostility. Conversely, attempts to discredit well-established scientific evidence for political, ideological or commercial purposes must be addressed with clarity, independence and scientific rigor.

Building and sustaining public trust therefore requires a collective commitment extending beyond individual researchers or institutions. Scientists, healthcare professionals, educators, scientific societies, policymakers and international organizations share responsibility for promoting transparent communication, protecting research integrity and ensuring that reliable knowledge remains accessible to all communities. In a world facing interconnected health, environmental and social challenges, the credibility of science is not merely an academic concern. It is a fundamental condition for effective public health action, international cooperation and informed societal decisions. Science must remain open to critical debate, but united in the defense of evidence, independent inquiry and the pursuit of knowledge as a shared global public good.

Integrity as an operational responsibility

Scientific integrity is essential for ensuring that research findings are reliable, transparent, and useful for improving healthcare. It is not limited to avoiding scientific misconduct, such as plagiarism, fabrication, or falsification of data. It also requires researchers and institutions to follow good scientific practices throughout the entire research process, from the initial design of a study to the publication and dissemination of its results.

Healthcare and research institutions have a responsibility to establish clear procedures that promote transparency, accountability, and scientific quality. These include the prospective registration of clinical studies when appropriate, clear criteria for authorship, disclosure of potential conflicts of interest, accurate reporting of research methods, and responsible management of scientific data. Researchers should explain how data were collected and analyzed, acknowledge the limitations of their studies, and make their methods sufficiently transparent to allow other scientists to critically evaluate their findings.

Peer review remains an important component of scientific publishing because it allows independent experts to assess the quality, relevance, and methodological soundness of a manuscript before publication. However, peer review alone cannot guarantee the accuracy of scientific results.

Research findings may contain errors or limitations that become apparent only after publication. For this reason, scientific integrity also depends on the possibility of independently verifying results, reproducing analyses when feasible, and correcting published information when new evidence or previously unrecognized errors emerge. A reliable scientific system should encourage continuous evaluation and improvement rather than assume that published findings are always definitive.

Scientific integrity also depends on the organizational culture of universities, hospitals, research institutions, and scientific societies. Researchers should work in environments where methodological concerns can be discussed openly and scientific opinions can be challenged respectfully. This is particularly important for students, junior researchers, and early-career healthcare professionals, who may hesitate to question established practices or decisions made by senior colleagues because of concerns about their professional development.

Institutions should therefore create opportunities for constructive scientific discussion and establish procedures through which researchers can report methodological problems or potential irregularities without fear of unfair consequences. Identifying an error should not automatically be associated with personal failure. In many cases, mistakes can provide opportunities to improve research methods and strengthen scientific quality. At the same time, institutions must maintain clear responsibilities and appropriate procedures for addressing serious misconduct, including deliberate manipulation of data, plagiarism, or intentional misrepresentation of research findings.

Practical measures can help support these principles. Research teams should have access to clear study protocols, appropriate ethical review, reliable data-management systems, and guidance on responsible scientific publication. When errors are identified after publication, journals and authors should work together to correct the scientific record transparently through appropriate corrections or retractions when necessary. These measures cannot eliminate every error, but they can improve the reliability of published evidence and strengthen confidence in scientific research.

An additional and equally important dimension of scientific integrity is equity. Opportunities to conduct research and publish scientific findings are not equally distributed across countries and institutions. Researchers working in settings with limited resources may face substantial barriers, including high publication costs, insufficient research funding, limited access to scientific journals, language difficulties, inadequate technological infrastructure, and restricted availability of statistical or methodological expertise. As a consequence, important scientific contributions from these settings may remain underrepresented in the international literature.

Promoting scientific integrity therefore requires more than establishing common research standards. It also requires creating fair opportunities for researchers worldwide to meet those

standards and contribute meaningfully to scientific progress. International partnerships should support access to research training, methodological expertise, data-analysis resources, and opportunities for scientific publication. Researchers from participating countries should be actively involved in defining research questions, designing studies, interpreting findings, and preparing scientific manuscripts.

In particular, institutions in low-resource settings should not be considered merely as locations for patient recruitment or data collection. Their professionals possess valuable knowledge of local health needs, disease patterns, healthcare organization, and practical barriers to implementing scientific recommendations. Recognizing this expertise and ensuring appropriate participation in research leadership, decision-making, and authorship are essential for developing more balanced and productive international collaborations.

Ultimately, scientific integrity and equity are closely connected. Reliable global health research depends on transparent methods, ethical conduct, responsible institutions, and the meaningful participation of researchers from different countries and healthcare settings. Strengthening these principles can improve the quality of scientific evidence, promote mutual trust, and ensure that scientific progress reflects the needs and experiences of populations worldwide.

The crisis of scientific publishing and the need for collective reform

Scientific publishing is a fundamental infrastructure of modern medicine. Journals make research visible, submit claims to expert scrutiny, preserve the scientific record and allow findings to inform education, clinical practice and public policy. Yet this system is facing a profound crisis of incentives, credibility, affordability and sustainability. The problem is not simply that more manuscripts are being published. It is that scientific value is too often confused with publication volume, journal prestige, citation metrics and the capacity to pay. When careers, funding and institutional reputation depend heavily on quantitative indicators, researchers may be encouraged to prioritize speed and productivity over originality, methodological rigor, replication, negative results and the long-term usefulness of their work.

The economic organization of publishing adds another dimension. Subscription barriers can prevent professionals and institutions from reading evidence they need, while high article-processing charges may exclude researchers who cannot afford to make their work openly accessible. Open access is an essential objective, but it should not become a system in which the ability to publish depends on financial means. Publicly funded research should, as far as possible, be accessible to the public without transferring disproportionate costs to authors or their institutions. Transparent pricing, equitable fee-waiver policies, institutional and funder support, nonprofit and society-led journals, responsible repositories and models that do not charge either readers or authors

deserve serious consideration. No single business model guarantees scientific quality; every model must be judged by its editorial independence, genuine peer review, transparency and fairness.

The growth of predatory publishing, fabricated manuscripts, purchased authorship, manipulated citations, fraudulent peer review and organized paper mills poses a more direct threat to trust. These practices can contaminate the published record and create misleading evidence that subsequently enters reviews, recommendations and clinical discussion. Emerging artificial intelligence tools may assist legitimate research and editorial workflows, but can also facilitate the industrial production of plausible-looking fraudulent content. Defending scientific publication therefore requires reliable editorial screening, independent expert review, transparent corrections and retractions, accessible mechanisms for reporting concerns, and cooperation among journals, research institutions, funders and scientific societies. At the same time, allegations must be assessed fairly. Suspicion, automation flags or reputational pressure alone should not replace documented evidence and due process.

The peer-review system itself also needs protection. Much of the intellectual work of reviewers and academic editors is carried out with limited recognition, insufficient training and increasing workloads. In some settings, commercial expectations and manuscript throughput can conflict with the time necessary for careful assessment. Institutions should recognize high-quality reviewing, editorial service, replication, data stewardship and methodological mentorship as real scientific contributions. Journals should make editorial responsibilities and conflicts of interest clear, provide adequate support to reviewers and avoid treating acceptance volume as the main measure of success. Publishing fewer, better-supported studies may serve science more effectively than producing an ever-growing number of articles whose reliability and practical relevance are uncertain.

This crisis is also a global-health equity issue. Research from countries with fewer resources may be overlooked because of publication fees, language barriers, unequal editorial representation or an excessive reliance on prestige-based evaluation. Yet knowledge generated in resource-limited settings may be precisely what is needed to improve implementation, resource efficiency and the resilience of healthcare systems worldwide. Fair authorship, inclusive editorial boards, multilingual dissemination, support for sound research regardless of institutional origin and equitable access to publication are therefore not optional gestures of solidarity. They are conditions for a more complete and reliable scientific record.

Reform requires collective action rather than indiscriminate hostility towards publishers or journals. Many editors, reviewers, scholarly societies and responsible publishers already invest substantially in research integrity. They should be partners in establishing enforceable standards.

Universities and funders must change evaluation systems that reward quantity over quality; publishers must demonstrate editorial accountability and explain the costs and conditions of publication; and researchers must reject purchased authorship, manipulated metrics and shortcuts that sacrifice integrity. The UNESCO Recommendation on Open Science emphasizes both removing barriers to knowledge and avoiding new inequalities created by publishing charges. Recent international initiatives against paper mills likewise show that no single actor can protect the scientific record alone. The ultimate goal is to restore publishing to its essential purpose: not selling visibility, but making trustworthy, independently assessed and socially useful knowledge available to everyone.

Communication without false certainty

Communication in times of scientific uncertainty requires clarity, transparency and intellectual honesty. It is essential to distinguish established evidence from preliminary findings, scientific interpretation and questions that remain unresolved. Health professionals, researchers and public institutions should avoid both exaggerated certainty and unnecessary alarm, and consider the limitations of available knowledge while explaining how new evidence may influence recommendations, clinical decisions and public health strategies. Scientific uncertainty should not be perceived as a weakness of science, but as an inherent part of a rigorous process in which conclusions are continuously tested, refined and, when necessary, revised.

Effective public communication should be continuous, inclusive and genuinely two-way. Trust cannot be built through institutional announcements alone, but requires meaningful dialogue with healthcare professionals, patients, communities and civil society. Listening to concerns, recognizing cultural and social differences, addressing misinformation without stigmatization and explaining the rationale behind recommendations are essential components of responsible communication. Accessible language, timely correction of errors, transparent disclosure of potential conflicts of interest and consistency between institutional messages and actions can strengthen credibility, particularly during prolonged health emergencies. Changes in recommendations should be communicated openly, explaining not only what has changed, but also why the available evidence now supports a different approach.

When scientific evidence informs public policy, a clear distinction should be maintained between the responsibilities of scientists and those of political decision-makers. Scientific expertise can assess risks, estimate potential outcomes, identify uncertainties and evaluate the expected consequences of different interventions. However, decisions about resource allocation, individual freedoms, collective responsibilities and acceptable levels of risk also involve ethical, social and political considerations that extend beyond scientific evidence alone. These choices must remain

the responsibility of accountable public institutions, guided by transparency, proportionality and the public interest. Protecting the independence of scientific advice while ensuring democratic accountability is essential to prevent the politicization of evidence and preserve public trust. Science should inform political decisions without being subordinated to electoral interests or ideological agendas, while political authorities should remain responsible for the choices they make and their consequences.

Key messages

- Trust grows when institutions explain what is known, what is uncertain and why recommendations change.
- Protect research integrity through transparent methods, disclosure of interests, independent scrutiny and correction of errors.
- Defend rigorous, evidence-based dissent while refusing to treat unsupported assertions as equivalent to scientific evidence.
- Make communication accessible and two-way, with clear accountability for decisions informed by science.
- Reform scientific publishing by rewarding research quality over volume, protecting genuine peer review, combating fraud and removing unjustified barriers to reading and publishing.

3
Resilient, equitable health systems

Resilience across ordinary care and emergencies

Resilience is frequently mistaken for the capacity to absorb a shock without visible failure. A more useful definition encompasses three abilities. maintaining essential services, adapting operations as circumstances change, and learning sufficiently to improve future performance. Systems that concentrate all resources on emergency response can inadvertently weaken prevention, chronic disease management or routine surgery.

Preparedness and routine quality improvement should be treated as connected activities. A hospital that regularly audits oxygen availability, referral delays, staffing and infection-control practices gains information that also matters during a surge. Conversely, emergency exercises can identify fragile routine processes before they fail. Resilience is thus a learned capability that develops through continuous observation, rehearsal, adaptation and transparent review rather than a reserve of equipment kept apart for exceptional circumstances.

The COVID-19 experience demonstrated that intensive-care capacity, diagnostics, primary care, logistics, leadership and staff protection are interconnected. Surge plans must define what can expand, which routine services must continue and who has authority to make trade-offs. Readiness should be rehearsed, not assumed [3, 4].

The workforce is the system

Buildings and technology cannot compensate for an exhausted or absent workforce. World Health Organization estimates indicate a considerable projected global shortage of health workers by 2030, with marked geographic disparities. Investment therefore requires education, funded posts, safe working conditions, retention, effective task-sharing and ethical cross-border recruitment. [5, 6]

Workforce planning must consider the full professional team. Nursing staff, laboratory personnel, pharmacists, cleaners, biomedical engineers, ambulance teams and community workers all contribute to safe care. If a hospital expands the number of beds without addressing supporting roles, the apparent increase in capacity may conceal a decline in quality. Retention programmes should investigate why professionals leave, whether they can practise safely, and whether career development is possible without permanent migration. International exchanges should contribute to capacity in both sending and receiving systems.

Cross-border collaboration should resist models in which richer systems solve immediate shortages by permanently extracting trained professionals from regions already facing critical gaps. Joint training, professional exchanges, recognition of competencies and support for local educational institutions can generate benefits in both directions [7].

Universal health coverage and the central role of primary healthcare

Universal health coverage (UHC) is a fundamental objective of global health and an essential expression of the right to health. It means that all individuals and communities should be able to access the quality health services they need, when and where they need them, without experiencing financial hardship. These services include health promotion, disease prevention, diagnosis, treatment, rehabilitation and palliative care throughout the life course. UHC is not achieved simply by introducing health insurance or formally declaring that certain services are covered. Effective coverage also depends on geographical accessibility, availability of qualified healthcare professionals, continuity of care, reliable access to essential medicines and diagnostic services, and the quality and safety of the care provided. A service that exists on paper but cannot be reached, is frequently unavailable, or does not meet acceptable standards cannot be considered truly accessible.Financial protection represents another essential dimension of universal health coverage. Even where public healthcare services are theoretically available, direct payments for medicines, diagnostic investigations, medical consultations and hospitalization may prevent individuals from seeking timely care. Indirect costs, including transportation, accommodation, lost working days and the financial burden placed on family caregivers, can create additional barriers, particularly for disadvantaged populations. In some settings, informal payments further undermine fairness and public trust. These obstacles frequently lead patients to delay consultations, interrupt treatments or avoid preventive services, allowing manageable conditions to progress into more serious illnesses. Consequently, the assessment of UHC must consider both effective service coverage and financial protection, rather than relying exclusively on indicators such as hospital capacity, insurance enrolment or healthcare expenditure [8]. Strong primary healthcare is the foundation of sustainable and equitable universal health coverage. Primary healthcare provides the first and most continuous point of contact between individuals, communities and health systems. It integrates preventive, promotive, curative, rehabilitative and palliative interventions and helps ensure that care is organized around people's needs rather than individual diseases or institutions. Effective primary healthcare supports immunization programmes, maternal and child health, reproductive healthcare, nutrition, early diagnosis of infectious diseases, screening for noncommunicable diseases, and the long-term management of chronic conditions such as diabetes, cardiovascular diseases and respiratory disorders. It also promotes health literacy,

encourages healthier behaviours and facilitates timely referral when specialized care is required. The importance of primary healthcare becomes particularly evident in populations facing geographical, social or economic disadvantages. Rural communities, remote settlements, migrants, older people and individuals living in poverty often experience significant difficulties accessing hospital-based services. Well-organized community health programmes, mobile healthcare units and appropriately supported digital services can help reduce these barriers. Community health workers, nurses, general practitioners, pharmacists, midwives and public-health professionals have complementary responsibilities in delivering accessible and culturally appropriate care. Their effectiveness, however, depends on adequate training, fair remuneration, professional supervision and integration into the wider health system. Community-based services should not become a lower-quality substitute for comprehensive healthcare in disadvantaged populations, but rather an effective means of extending essential services while maintaining professional standards.

Primary healthcare must also be supported by functioning diagnostic laboratories, reliable medicine supply chains, effective health information systems and accessible referral networks. The continuity between community services, primary care facilities and hospitals is particularly important. Early identification of a serious infection, for example, has limited value if the patient cannot access microbiological investigations, appropriate antimicrobial treatment or emergency hospital care. Similarly, screening for hypertension or diabetes produces little benefit without sustained access to medicines, follow-up consultations and patient education. Universal health coverage therefore requires an integrated health system in which prevention, early diagnosis, treatment and continuity of care reinforce one another. An effective primary healthcare system also strengthens preparedness and resilience during public-health emergencies. Healthcare professionals working within communities are often the first to recognize unusual patterns of illness, detect emerging infections, communicate preventive recommendations and identify vulnerable individuals. Established relationships between local healthcare teams and communities can improve trust, support vaccination programmes and facilitate the implementation of public-health interventions during epidemics and pandemics. Investments in primary healthcare therefore generate benefits beyond routine service delivery, contributing to surveillance, emergency response and the capacity of health systems to maintain essential services during crises.

Nevertheless, universal health coverage cannot be achieved through primary healthcare alone. Hospitals, specialist services, emergency care, surgical capacity, intensive care and advanced diagnostic facilities remain indispensable components of a comprehensive system. The objective is not to prioritize community healthcare at the expense of specialized medicine, but to establish an appropriate balance between different levels of care. Strong primary healthcare can prevent

avoidable complications, reduce unnecessary hospital admissions and improve the use of specialist resources, allowing hospitals to concentrate on conditions requiring greater clinical complexity. This integrated approach is especially important in settings where financial and human resources are limited.

Progress towards universal health coverage also requires sustained political commitment, transparent governance and appropriate financing. Governments must identify essential health priorities, allocate resources according to population needs and progressively expand access while protecting households from catastrophic and impoverishing health expenditure. Particular attention should be given to populations that are systematically underserved, including those affected by poverty, displacement, discrimination or geographical isolation. Decisions regarding the allocation of resources should be informed by scientific evidence, epidemiological needs and equity considerations rather than short-term political interests. Reliable procurement systems, investment in healthcare workers and mechanisms for evaluating the quality of services are equally necessary to ensure that financial resources translate into measurable health benefits.

Importantly, the path towards universal health coverage cannot be identical in every country. Differences in economic resources, disease burden, demographic structure, infrastructure and workforce availability require locally adapted strategies. Countries with limited resources may develop innovative approaches to community-based care, task-sharing, decentralized service delivery and efficient resource utilization. These experiences can provide valuable lessons for better-resourced health systems, demonstrating that international collaboration should promote reciprocal learning rather than a one-directional transfer of expertise. However, efficiency must not be confused with the normalization of inadequate funding or unacceptable standards of care. Finally, universal health coverage should be understood as a continuous process of strengthening health systems, reducing inequalities and translating the right to health into effective access to quality services. Its success should be evaluated not only by the number of people formally covered, but also by whether preventable diseases are avoided, conditions are diagnosed early, treatments remain accessible, and families are protected from financial hardship. Public accountability must continually examine who remains excluded, which services are delayed or unsafe, and whether investments are producing meaningful improvements in population health. The World Health Organization and World Bank monitoring framework provides an important basis for assessing progress through service coverage and financial protection indicators, while recognizing the need for national adaptation [8].

Universal health coverage is therefore more than a healthcare financing objective. It represents a commitment to social justice, institutional responsibility and human dignity. By placing strong, integrated primary healthcare at the centre of health-system development, countries can move towards a model in which access to essential care depends increasingly on people's health needs rather than their income, geographical location or social circumstances.

Essential surgery as an equity indicator

Access to timely, safe, and effective surgical and anaesthesia services is an essential component of a well-functioning healthcare system. Surgical care is not limited to the performance of an operation, but depends on the coordinated functioning of several services, including primary healthcare, emergency medical systems, diagnostic facilities, transportation networks, blood transfusion services, nursing care, infection prevention, anaesthesia, and postoperative monitoring. The ability to provide safe surgical treatment therefore reflects the overall capacity of a health system to deliver essential healthcare services.

The Lancet Commission on Global Surgery highlighted the importance of improving access to safe, affordable, and timely surgical and anaesthesia care worldwide. It also provided a framework for identifying major gaps in surgical services and assessing the capacity of health systems to respond to the needs of their populations. This framework emphasizes that surgical care should be considered an essential part of universal health coverage rather than a specialized service available only in well-resourced healthcare settings [9].

Surgical conditions represent an important public health challenge because they affect individuals across all age groups and socioeconomic backgrounds. Emergency abdominal conditions, traumatic injuries, obstetric complications, congenital abnormalities, and other diseases requiring surgical treatment can lead to preventable disability or death when appropriate care is unavailable or delayed. In many settings, the main problem is not the absence of an effective surgical procedure, but the inability of patients to reach a healthcare facility where that procedure can be performed safely and without excessive delay.

Geographical distance is one of the most important barriers to accessing surgical care. People living in rural or remote areas may need to travel considerable distances to reach hospitals with functioning operating theatres and qualified surgical teams. Poor road infrastructure, limited ambulance services, and inadequate communication between healthcare facilities can further delay treatment. These difficulties become particularly important in time-sensitive emergencies, when delays in diagnosis, stabilization, or surgical intervention may significantly worsen clinical outcomes.

Financial barriers also contribute to inequalities in surgical care. Even when surgical procedures are available, patients may face substantial expenses related to transportation, diagnostic investigations, medicines, hospitalization, and postoperative care. In healthcare systems where patients must pay directly for essential services, these costs may lead individuals and families to postpone treatment or avoid seeking medical attention. As a result, conditions that could have been treated effectively at an earlier stage may progress to more severe disease, requiring more complex interventions and longer hospitalization.

The quality of surgical care depends on much more than the availability of surgeons and operating theatres. Safe anaesthesia requires trained professionals, appropriate monitoring equipment, a reliable oxygen supply, essential medicines, and the capacity to recognize and manage complications. Surgical procedures also depend on the availability of sterile instruments, functioning equipment, appropriate antimicrobial prophylaxis when indicated, and effective infection prevention and control measures.

Postoperative care is equally important. Patients may require close clinical observation, pain management, fluid and nutritional support, early recognition of complications, and access to intensive care or further surgical treatment when necessary. A technically successful operation cannot guarantee a favorable outcome if the healthcare system is unable to provide adequate postoperative monitoring or respond promptly to clinical deterioration.

These considerations illustrate why surgical care should be approached as a coordinated process rather than an isolated technical intervention. Improving one component of the system may have limited benefits when other essential services remain inadequate. For example, increasing the number of operating theatres may not substantially improve access to surgery if hospitals lack trained anaesthesia personnel, blood products, reliable sterilization services, or sufficient nursing staff.

Similarly, expanding surgical capacity without strengthening emergency referral systems may have little impact on patients who cannot reach hospitals in time. Effective surgical planning should therefore consider the entire patient pathway, beginning with the recognition of symptoms and the initial clinical assessment, followed by transportation, diagnosis, treatment, postoperative care, and rehabilitation when necessary.

Strengthening essential surgical services can also produce benefits that extend beyond the surgical department. Reliable emergency transportation, laboratory diagnostics, blood transfusion services, infection prevention programmes, and critical care facilities support the management of many other acute and chronic conditions. Improvements in surgical infrastructure may therefore contribute to better maternal healthcare, trauma management, emergency preparedness, and the overall resilience of healthcare systems.

An important challenge in global surgery is the unequal distribution of healthcare professionals, infrastructure, and financial resources. Advanced surgical services are frequently concentrated in major urban hospitals, while district hospitals and healthcare facilities serving remote populations may have limited personnel, equipment, and diagnostic capacity. This concentration can create substantial differences in access to care within the same country, particularly between urban and rural communities.

Reducing these inequalities does not necessarily require the immediate development of highly specialized surgical centres in every region. A more effective approach may involve strengthening essential surgical services at district level, improving the capacity to recognize and stabilize critically ill patients, establishing reliable referral networks, and ensuring that complex cases can be transferred safely to facilities with appropriate expertise.

District hospitals can play an important role in providing essential and emergency surgical care when they have adequately trained personnel, safe anaesthesia services, basic diagnostic capabilities, and access to the necessary equipment and supplies. At the same time, clear referral pathways are needed to ensure that patients requiring more complex procedures receive timely treatment at higher-level facilities. Effective communication between different levels of care can reduce unnecessary delays and improve continuity of treatment.

Workforce development is another fundamental priority. Expanding access to surgery requires not only surgeons, but also anaesthesiologists, nurses, operating theatre personnel, laboratory professionals, biomedical technicians, and other healthcare workers involved in perioperative care. Training programmes should aim to develop practical competencies, promote teamwork, and support the retention of qualified professionals in underserved areas.

International cooperation can contribute to these objectives through educational partnerships, professional exchanges, shared clinical experience, and support for local training programmes. However, sustainable improvements require long-term investment in local institutions rather than exclusive reliance on temporary external missions. Training activities should strengthen the ability of healthcare teams to provide safe care independently and adapt clinical practices to the resources available.

The development of surgical services must also be guided by reliable information about population needs and healthcare performance. Useful indicators include access to timely essential surgery, the availability of an appropriately trained surgical and anaesthesia workforce, the volume of procedures performed, perioperative outcomes, and the financial consequences of surgical treatment for patients and families. These measures can help identify inequalities, guide resource allocation, and monitor the effectiveness of health system improvements.

Nevertheless, numerical indicators should be interpreted carefully. A higher number of surgical procedures does not necessarily indicate better healthcare if the quality and safety of treatment are inadequate. Similarly, the existence of a functioning operating theatre does not guarantee effective access when essential supplies are frequently unavailable or patients cannot afford treatment. Evaluation should therefore consider availability, accessibility, quality, safety, and affordability together.

Clinical protocols and surgical guidelines can support the delivery of consistent, evidence-informed care, but their implementation must take account of local epidemiology, available resources, and organizational capacity. Adaptation to different healthcare settings is necessary, particularly in regions where access to diagnostic equipment, essential medicines, or specialist services is limited. However, resource limitations should not be used to justify preventable harm or permanently lower expectations of patient safety. Instead, identifying these limitations should provide a starting point for targeted improvements and progressive strengthening of surgical services.

Finally, equitable access to essential surgery is both a healthcare priority and an indicator of broader health system performance. A system that can recognize surgical emergencies, ensure timely referral, provide safe operative and anaesthetic care, and support recovery demonstrates capacities that are valuable across many areas of medicine. Improving these services requires coordinated investment in infrastructure, workforce development, education, financing, and quality assurance.

From a global health perspective, the objective is not simply to increase the number of surgical procedures performed, but to ensure that patients can receive appropriate treatment when they need it, regardless of their geographical location or socioeconomic circumstances. Strengthening essential surgical care is therefore an important step toward reducing preventable mortality and disability, advancing universal health coverage, and building more equitable and resilient healthcare systems worldwide.

Non-communicable diseases: the long-term global burden

Global health cannot be understood only through outbreaks and other acute emergencies. Cardiovascular diseases, cancers, diabetes and chronic respiratory diseases account for a major share of premature illness, disability and deaths worldwide. According to the World Health Organization’s 2025 noncommunicable-disease factsheet, the burden is especially consequential in low- and middle-income countries, where prevention, early diagnosis and continuity of treatment may be more difficult to secure. These conditions also interact with poverty. Illness can reduce earning capacity while long-term treatment costs place pressure on families [10].

Many effective responses are well established, but implementation is uneven. Reducing tobacco exposure, harmful alcohol use, unhealthy diets and air pollution require public policy as well as individual counselling. Hypertension screening, affordable essential medicines, reliable cancer diagnostic pathways and integrated diabetes care can prevent avoidable complications, but their benefits depend on continuity. A one-time campaign is not an adequate substitute for functioning primary care, longitudinal records, referral pathways and uninterrupted access to treatment.

The COVID-19 pandemic illustrated how quickly routine chronic-disease services may deteriorate when systems concentrate on a single threat. Resilience therefore requires protecting ongoing care during emergencies. Programmes should measure not only the number of people screened or diagnosed, but also retention in care, treatment access, disease control and preventable complications. A comprehensive global-health agenda must address infectious and non-communicable diseases together rather than treating them as competing priorities.

Financing and accountability

Financial protection is a clinical issue because catastrophic out-of-pocket costs delay treatment and impoverish families. Universal health coverage requires attention to service quality, continuity and financial hardship, not simply nominal enrolment [11].

Financial protection should be examined from the patient's perspective. Even when consultation or surgery is formally covered, transport, medicines, diagnostic tests, accommodation and lost earnings may impose unaffordable costs. Delays can cause disease to become more severe, increasing both clinical risk and eventual expenditure. Evaluation therefore needs patient-centred measures of access and hardship alongside expenditure statistics. Such information is essential when deciding whether reforms make services genuinely more equitable.

Health spending should be assessed through opportunity costs, distributional effects and long-term sustainability. Transparent procurement, auditability and community oversight help prevent scarce resources from being diverted away from patient needs.

Mental health as a core component of global health

Mental health is an essential part of health and human functioning, not a secondary issue that matters only during conflict or disaster. Depression, anxiety and other mental disorders can affect education, employment, relationships, physical health and the ability to participate fully in community life. The World Health Organization’s 2025 report, World Mental Health Today, documents substantial unmet need and persistent gaps in financing, workforce and quality of care. Stigma and discrimination can compound these barriers, particularly when seeking psychological or psychiatric support carries social or professional consequences. [12]

An equitable response requires integrating mental health into primary healthcare and community services, while ensuring access to specialist care for people with more complex needs. Professionals need appropriate training, referral options and practical tools for recognizing common conditions without turning every form of distress into a medical diagnosis. Mental health promotion also depends on social conditions. Violence, insecure employment, poverty, exclusion and unstable housing may undermine well-being even where clinical services exist.

Progress should be evaluated through access, continuity, quality, patients' experiences and functional outcomes, not only the number of consultations delivered. Schools, workplaces and community organizations have complementary roles, but their actions should be evidence-informed and respectful of individual rights. Integrating mental health into the wider health agenda is both an equity commitment and a requirement for genuinely people-centred systems.

Maternal, child and adolescent health across the life course

Maternal, newborn, child and adolescent health offers a particularly clear measure of whether the promises of global health reach people across the life course. Preventable maternal deaths, complications of childbirth, neonatal illness and disruptions to childhood services often reflect weaknesses in access, transport, staffing, referral networks and financial protection. The 2025 joint estimates of WHO, UNICEF, UNFPA, the World Bank Group and UNDESA on maternal mortality illustrate the continuing importance of safe pregnancy and childbirth care [13].

A sustainable approach links antenatal care, skilled birth attendance, emergency obstetric services, newborn care, breastfeeding support, nutrition, routine immunization and adolescent-friendly services. Sexual and reproductive health information should be accessible, respectful and adapted to local needs. Services must be clinically safe and designed to preserve dignity and informed decision-making. Communities and families can support participation, but should not replace a young person's or patient's rights and autonomy.

Progress requires more than counting facility visits. Relevant indicators include timely referral, continuity of essential services, preventable complications, respectful care and the experience of underserved groups. Investments made early in life can generate benefits for health, education and economic opportunity over many years, making maternal, child and adolescent health central to resilience and equitable development.

International health financing and the consequences of donor withdrawal

Global health security depends on institutions capable of operating before, during, and after emergencies. Yet the financing of multilateral health agencies and humanitarian organizations remains vulnerable to abrupt political decisions and changes in donor priorities. The recent

international funding crisis was particularly serious because of the sudden interruption of financial support from the United States, historically the largest governmental contributor to several major global health programmes. In January 2025, the United States announced its withdrawal from the World Health Organization. The US government declared the withdrawal complete on 22 January 2026 and confirmed that it had terminated its funding to the Organization [14]. WHO had already warned in April 2025 that unpaid US contributions and reductions by other donors were creating a projected salary gap of US$560–650 million for 2026–2027, requiring organizational restructuring and workforce reductions [15].

However, the crisis also exposed a pre-existing structural weakness in the international health financing system such as the excessive dependence of essential global health programmes on the contributions of a single country or a small number of major donors. Although substantial US financial support had enabled important achievements in disease prevention, vaccination, surveillance, research, and humanitarian assistance, it may already have represented a structural vulnerability that such a large proportion of internationally relevant health activities depended on the continued political and financial commitment of one government. Programmes designed to protect global health should ideally rest on a sufficiently broad, predictable, and collectively supported financial foundation. When essential services depend disproportionately on a limited number of contributors, a change in national political priorities can rapidly become an international health crisis. The sudden withdrawal of funding was therefore the immediate trigger of the disruption, but the underlying concentration of financial responsibility had made the system vulnerable long before that decision.

These developments are part of a wider contraction in international assistance. An OECD assessment of the US fiscal year 2026 budget request documented proposed deep reductions in bilateral global health programmes and humanitarian assistance, including the absence of proposed allocations to WHO, Gavi, and the Global Fund [16]. The distinction between a budget proposal, an approved allocation, and expenditure actually disbursed remains essential. Nevertheless, abrupt interruptions and persistent uncertainty in financing can undermine disease surveillance, vaccination campaigns, emergency preparedness, humanitarian health services, and the ability of local institutions to retain trained healthcare professionals. The consequences are particularly serious in countries where health systems already face limited resources, political instability, conflict, displacement, or recurrent infectious disease outbreaks.

Political authorities retain responsibility for determining public expenditure and may legitimately demand efficiency, transparency, accountability, and institutional reform. Nevertheless, these objectives should be pursued through responsible transitions that minimize disruptions to essential international health functions. At the same time, the international community must recognize

that sustainable global health cannot depend primarily on the willingness of a single country to maintain its financial commitments indefinitely. Financial responsibility for global health should be more broadly shared among countries and other accountable contributors, reflecting their respective capacities, while protecting the independence and public-interest mission of international institutions. Diversified funding sources, stronger predictable contributions, transparent governance, contingency mechanisms, and greater investment in local health-system capacity are necessary to reduce vulnerability to future political and financial shocks.

Ultimately, this crisis offers a broader lesson about international solidarity. Global health institutions must not only be effective and accountable; they must also be financially resilient enough to withstand changes in individual governments and donor priorities. The costs of fragmented or abruptly interrupted financing are rarely borne solely by the institutions losing their resources. They are ultimately transferred to patients, healthcare workers, and vulnerable communities. A truly collective approach to global health requires collective financial responsibility, because programmes intended to protect the health of humanity should not depend excessively on the decisions of any single nation.

Key messages

- Protect predictable financing for humanitarian health responses, while requiring transparency, accountability, and effective local implementation.
- Resilient health systems protect essential services during both ordinary pressures and major emergencies.
- Invest in the entire workforce, including safe conditions, training, retention and supporting professions.
- Treat timely, safe and affordable emergency and surgical care as a measure of health-system equity.
- Monitor real access, patient safety and financial hardship, not infrastructure or service volumes alone.

4
What the COVID-19 pandemic taught us

A pandemic that exposed interdependence

The COVID-19 pandemic revealed how rapidly a local outbreak can become a global crisis when pathogens circulate through interconnected systems of travel, work, trade and social interaction. It also demonstrated that the consequences of an infectious threat extend well beyond the number of infections recorded. Healthcare delivery, education, employment, scientific research, supply chains and community relationships were simultaneously affected. The pandemic therefore provides a particularly important case study for understanding why global health requires coordinated preparedness, trustworthy institutions and practical international solidarity [17, 18].

The lessons of COVID-19 should be approached with both humility and critical reflection. Responses differed across countries and changed as evidence about transmission, risk and preventive measures developed. Some decisions were taken under exceptional uncertainty, while others reflected weaknesses in preparedness, communication or governance. Retrospective assessment should distinguish what was reasonably known at a particular moment from what became apparent later. The objective is not to construct a simple narrative of success and failure, but to identify improvements that can strengthen responses to future emergencies.

Preparedness must exist before the emergency

The pandemic exposed gaps in early warning systems, public health coordination, laboratory capacity, personal protective equipment, oxygen availability and workforce preparedness. Written emergency plans were often insufficient where institutions lacked trained personnel, rehearsed procedures, reliable procurement mechanisms or authority to act promptly. Preparedness is therefore a sustained operational capacity rather than a document prepared for an exceptional event [17, 19].

An effective preparedness strategy combines surveillance, diagnostic capacity, adaptable clinical pathways, community engagement and well-defined responsibilities across health-system levels. Simulation exercises and after-action reviews help identify vulnerabilities before they are repeated. Preparedness also requires protection of essential routine services, since the redirection of resources to emergency response can delay other necessary forms of care.

Scientific collaboration and the limits of knowledge

COVID-19 showed the value of rapidly sharing pathogen sequences, epidemiological findings, clinical observations and research protocols. International collaboration accelerated the development and assessment of diagnostics, vaccines and treatments. At the same time, rapidly circulating preliminary findings, inconsistent study quality and changing recommendations exposed the difficulty of communicating science while evidence is still developing [3, 18, 20].

Uncertainty must not be hidden or confused with the absence of expertise. Scientific advice should explain the strength and limitations of evidence, update recommendations when findings change, and separate empirical conclusions from policy choices involving ethical, social or economic trade-offs. A united scientific community is not one that suppresses disagreement, but one that shares methods, evaluates competing hypotheses rigorously and corrects errors transparently.

Trust, communication and the social context

Technical recommendations do not operate independently of trust. Public cooperation depends on whether institutions communicate clearly, acknowledge uncertainty, explain the reasons for changes and engage communities respectfully. Contradictory messages, politicized claims and misinformation can undermine confidence even when public health measures have a strong scientific basis. Communication must therefore be considered an essential component of preparedness rather than an activity added after scientific decisions have been made [17, 18].

Health measures also have social consequences. Restrictions on mobility, interruptions to schooling and employment, isolation, and the disruption of routine care may affect populations differently. Protecting public health requires proportionality, attention to vulnerable groups and mechanisms for reviewing both intended benefits and unintended harms. Community participation improves the acceptability and practical design of interventions.

Health workers and continuity of essential services

Healthcare workers carried extraordinary clinical and organizational responsibilities during the pandemic. Inadequate protection, prolonged workloads and workforce shortages placed strain on services and professionals. The experience demonstrated that workforce safety, sufficient staffing, appropriate training and mental well-being are core elements of health-system resilience, not secondary concerns [19].

Institutions must also preserve essential care during crises. Emergency surgery, maternal and child healthcare, management of chronic conditions, vaccination and other indispensable services should not be treated as expendable whenever an infectious threat emerges. Preparedness plans

should identify minimum service levels, alternative pathways and transparent processes for allocating scarce resources.

Equity in access to countermeasures

One of the most consequential lessons of COVID-19 concerns inequitable access to vaccines, diagnostics, treatments and essential supplies. Scientific innovation can occur at unprecedented speed while access to its benefits remains highly uneven. Differences in purchasing power, manufacturing capacity, distribution infrastructure and political influence shaped how quickly populations could obtain health technologies [17, 18, 20].

Future preparedness should therefore include regional manufacturing capacity, resilient supply chains, transparent allocation principles, appropriate technology transfer and stronger participation of underrepresented settings in global decisions. Equity is not only a moral objective: leaving populations without timely access to effective measures can prolong health emergencies and deepen social and economic harm.

Independent scientific audits and the risk of politicizing public health

One of the most important lessons of COVID-19 is that every major public health emergency should be followed by a rigorous, independent and transparent evaluation of what happened. Such an audit is not an exercise in assigning political blame or judging decisions solely with the benefit of hindsight. Its primary purpose is to understand which decisions were taken, on the basis of which information, under what constraints, with what consequences, and how healthcare systems can perform better in a future emergency. The World Health Organization and the European Centre for Disease Prevention and Control have developed methodologies for COVID-19 after-action reviews, designed to identify strengths, weaknesses and practical improvements in preparedness and response [21, 22].

An effective audit should examine the entire response, including surveillance, early warning, scientific advice, emergency coordination, hospital capacity, protection of healthcare workers, infection prevention, communication, and continuity of essential services. It should assess both the benefits and the unintended consequences of interventions, distinguish failures of planning from reasonable decisions taken under uncertainty, and consider whether alternative actions were realistically available at the time. Findings must be based on documented evidence and transparent criteria, rather than selective quotations, retrospective certainty or the political preferences of those conducting the review. Public health inevitably involves political decisions, because governments are accountable for allocating resources, balancing competing public interests and protecting fundamental rights. Political responsibility is legitimate and necessary. Politicization becomes

harmful, however, when scientific evidence is selected, interpreted or publicly presented primarily to reinforce an ideological position, gain electoral advantage, discredit opponents or defend previous choices. Under those conditions, even a potentially valuable review can lose credibility and become an extension of political confrontation rather than a mechanism of institutional learning. This risk is not confined to any single party, country or political tradition.

The safeguard is not to exclude elected institutions from oversight, but to ensure that scientific evaluation is methodologically independent of partisan objectives. Audit teams should include professionals with relevant and diverse expertise, disclose conflicts of interest, publish their remit and methods, provide access to verifiable records while protecting personal data, and distinguish clearly between facts, uncertainties and policy judgments. Where expert interpretations differ, reasoned disagreement should be documented fairly and evaluated on its merits. Scientific independence must protect evidence-based dissent without suggesting that all claims are equally supported by evidence.

The credibility of an audit ultimately depends on what happens after its conclusions are published. Each major finding should lead, where justified, to a corrective action with an identified responsible institution, a realistic deadline, measurable indicators and a plan for reassessment. Improvements might include stronger surveillance systems, clearer emergency communication, better protection for healthcare workers, stockpile management, or mechanisms to preserve non-emergency care. Findings should be accessible to professionals and the public, including when they reveal uncomfortable institutional shortcomings. The objective is not to rewrite the past in accordance with present political interests, but to reduce the likelihood of repeating avoidable mistakes. Learning from COVID-19 therefore requires a distinction between democratic accountability and partisan instrumentalization of scientific review. An independent audit should be demanding, critical and willing to identify serious shortcomings, while remaining fair to the evidence and the context of the decisions examined. When conducted in this spirit, it can strengthen public trust, improve preparedness and turn difficult experience into lasting institutional capacity.

From lessons identified to lessons implemented

The value of reflecting on COVID-19 depends on whether the lessons learned are translated into meaningful institutional change. Governments, healthcare organizations and international institutions should move beyond declarations of preparedness to identify specific vulnerabilities, define measurable objectives, assign responsibilities and allocate adequate resources. Progress should be regularly assessed through transparent monitoring mechanisms to determine whether reforms have improved the capacity of health systems to prevent, detect and respond to

emerging threats. After-action reviews, independent evaluations, simulation exercises and multi-disciplinary assessments can help distinguish improvements achieved from commitments that remain unfulfilled [23]. Equally important is the involvement of frontline healthcare professionals, scientific communities and civil society in evaluating preparedness strategies, since their experience can reveal operational weaknesses overlooked at the institutional level. Lessons learned should inform national policies, strengthen international cooperation and encourage adaptable systems capable of responding to different epidemiological and socioeconomic circumstances.

The central lesson is that pandemic readiness cannot be built through isolated investments introduced only during a crisis. Sustainable preparedness requires continuous investment in strong everyday healthcare services, resilient public health infrastructures, well-trained and protected professionals, reliable surveillance systems, trustworthy scientific communication and equitable access to essential medical resources. It also requires institutions capable of coordinating decisions across sectors, sharing scientific evidence openly and maintaining public confidence through transparency and accountability. Particular attention should be given to reducing inequalities, since health emergencies disproportionately affect populations already experiencing limited healthcare access and socioeconomic disadvantage. Preparedness must therefore be understood not simply as the capacity to respond rapidly to infectious disease outbreaks, but as a broader commitment to resilient, inclusive and sustainable health systems. When scientific knowledge, institutional responsibility, professional competence and international solidarity are strengthened together, societies become better equipped not only to confront future pandemics but also to address complex emergencies, including climate-related disasters, humanitarian crises and disruptions to essential healthcare services.

Key messages

- Preparedness must be funded, rehearsed and evaluated before the next emergency, not written only during a crisis.
- Share emerging evidence promptly while acknowledging uncertainty and correcting conclusions as knowledge evolves.
- Protect health workers and maintain essential non-emergency services throughout a public health response.
- Measure whether lessons from COVID-19 have become operational changes, especially for underserved populations.
- Use independent, evidence-led after-action audits to identify preventable errors and implement corrections, without turning scientific learning into partisan confrontation.

5
Education as shared global infrastructure

Education as a global public good

Knowledge differs fundamentally from many material resources. While physical goods may be consumed, depleted, or become unavailable through use, knowledge can be shared, reproduced, critically examined, and progressively enriched without diminishing its value to those who already possess it. Indeed, its usefulness often increases when it is exchanged among professionals, tested in different environments, and adapted to new scientific, cultural, and organizational contexts. Scientific progress depends not only on the generation of new evidence but also on the capacity to make existing knowledge accessible, understandable, and applicable to the people and institutions that can benefit from it.

In global health, the sharing of knowledge represents one of the most powerful opportunities for strengthening healthcare systems. Educational cooperation can connect professionals working in different countries, facilitate the exchange of clinical experiences, and support the dissemination of evidence-based approaches to prevention, diagnosis, treatment, and healthcare organization. It can also encourage critical reflection, allowing established practices to be reconsidered in light of emerging evidence or experiences developed in other settings.

However, the possibility of acquiring, interpreting, and applying scientific knowledge remains profoundly unequal. Access to professional education is influenced by financial resources, geographical location, language, technological infrastructure, institutional support, professional responsibilities, and opportunities for mentorship. Healthcare professionals working in well-resourced academic institutions may benefit from extensive libraries, specialized training programmes, international conferences, and established research networks. By contrast, colleagues working in rural facilities, district hospitals, or economically disadvantaged settings may encounter substantial barriers to continuing education, even when their motivation and professional commitment are equally strong.

These inequalities are not simply a matter of individual opportunity. They reflect broader differences in how educational resources, scientific infrastructure, and professional development opportunities are distributed across healthcare systems. Tuition fees, subscription costs, travel expenses, limited internet connectivity, inadequate access to updated scientific literature, and the absence of protected learning time can restrict participation in education. Language barriers may

further limit access when important scientific information is available primarily in a small number of widely used academic languages.

A borderless approach to global health education must therefore recognize these obstacles as structural challenges that educational institutions and international networks have a responsibility to address. Rather than assuming that every professional can participate under the same conditions, educational programmes should be designed with the diversity of learners' circumstances in mind. Accessibility should become a fundamental principle of educational planning, not an additional feature introduced after materials and activities have already been developed.

This requires moving beyond the idea that making information publicly available is sufficient to ensure equitable access to knowledge. A scientific article, recorded lecture, or educational manual may be freely accessible online but remain practically unusable for professionals who lack reliable connectivity, sufficient time, appropriate language support, or the background knowledge needed to interpret its content. Meaningful accessibility requires attention not only to whether information can be obtained, but also to whether it can be understood, critically evaluated, and incorporated into professional practice.

Open educational resources offer important opportunities to reduce some of these barriers. Freely accessible manuals, clinical learning materials, recorded lectures, educational presentations, practical guides, and digital training programmes can allow scientific knowledge to reach professionals who might otherwise be excluded from formal educational opportunities. Such resources may be particularly valuable when they can be downloaded, consulted repeatedly, shared within institutions, and used independently of expensive subscription services or continuous internet access.

Nevertheless, openness should not be confused with educational quality. The value of an educational resource depends on its scientific reliability, clarity, relevance, and capacity to support meaningful learning. Freely accessible information can contribute to professional development only when its content is accurate, transparent, appropriately referenced, and consistent with the best available evidence. Poorly structured or outdated educational materials may create confusion, reinforce ineffective practices, or encourage the inappropriate application of recommendations.

High-quality educational resources should therefore explain not only what is recommended, but also why particular conclusions are supported by scientific evidence. Learners benefit from understanding the reasoning underlying clinical and public health decisions, the limitations of available studies, and the circumstances in which different approaches may be appropriate. Scientific uncertainty should be communicated clearly rather than concealed behind overly simplified

recommendations. Recognizing uncertainty is an essential component of critical thinking and professional responsibility.

Educational materials should also help learners distinguish between established evidence, emerging findings, expert interpretation, and context-dependent decisions. This distinction is particularly important in global health, where differences in epidemiology, available resources, healthcare infrastructure, and professional competencies may influence the applicability of scientific recommendations. An intervention supported by strong evidence in one environment may require adaptation before it can be implemented safely and effectively elsewhere.

The educational value of a resource is therefore closely connected to its practical relevance. A concise downloadable guide may offer substantial benefits when it includes clearly defined learning objectives, explanations of fundamental concepts, relevant clinical examples, decision-making pathways, and practical considerations for implementation. Case-based learning can be especially useful because it connects scientific principles with situations that healthcare professionals may encounter in their everyday work. By examining realistic scenarios, learners can develop their ability to interpret evidence, recognize uncertainty, and make informed decisions under different conditions.

Educational resources should also be designed to facilitate progressive learning. Not all participants enter an educational programme with the same knowledge, experience, or professional responsibilities. Introductory materials may be necessary to establish common foundations, while more advanced content can support specialized competencies and critical scientific discussion. Modular educational structures can help learners select topics relevant to their needs and engage with material at a pace compatible with their clinical duties and available time.

Regular review and updating are equally important. Scientific knowledge evolves, and educational resources may become outdated as new evidence, technologies, diagnostic approaches, or therapeutic strategies emerge. Each resource should ideally identify its date of publication or revision, indicate the principal evidence supporting its content, and provide a mechanism for future updates. Transparent revision processes strengthen credibility and help users understand whether the information remains applicable to current practice.

Language represents another essential dimension of educational equity. Scientific communication frequently relies on English, which facilitates international exchange but may also create barriers for healthcare professionals who have limited opportunities to study or work in that language. Multilingual educational materials can broaden participation and support the understanding of complex scientific concepts, particularly when learners need to translate theoretical knowledge into practical clinical decisions.

Translation, however, requires more than the literal conversion of words from one language to another. Clinical terminology, professional roles, healthcare organization, and cultural expectations may differ substantially among countries. An accurate educational translation must preserve scientific meaning while ensuring that explanations remain comprehensible and relevant to the intended audience. Whenever possible, translation and adaptation should involve healthcare professionals familiar with local terminology, clinical practice, and institutional structures.

The involvement of local professionals can also improve the relevance of educational examples and practical recommendations. Clinical scenarios developed in highly specialized institutions may not reflect the conditions encountered in district hospitals or resource-limited healthcare facilities. Adaptation can help learners identify the essential principles underlying a recommendation and consider how these principles may be implemented with different diagnostic tools, staffing models, or organizational resources.

Digital technologies have created important opportunities for expanding access to professional education. Online courses, recorded webinars, virtual conferences, digital libraries, and interactive learning platforms can connect healthcare professionals across geographical boundaries and reduce the need for travel. They can also facilitate continuing education for individuals who cannot attend traditional academic programmes because of professional responsibilities, family commitments, financial limitations, or geographical isolation.

However, digital education can reproduce existing inequalities when programmes assume universal access to high-speed internet, modern devices, reliable electricity, or advanced digital literacy. Educational initiatives should therefore consider low-bandwidth formats, downloadable materials, mobile-compatible resources, and alternatives that can be used without continuous connectivity. Providing recordings and asynchronous learning opportunities can allow professionals to access educational content at times compatible with clinical duties and different time zones.

Affordability is another important consideration. Although developing and maintaining educational resources requires investment, international cooperation can help distribute costs and avoid unnecessary duplication. Shared educational platforms, institutional partnerships, open-access publishing initiatives, and collaborative development of teaching materials may allow scientific knowledge to reach wider audiences without imposing substantial financial burdens on individual learners.

Accessibility must also include the needs of professionals with disabilities. Educational materials should be designed, where feasible, to support different visual, auditory, motor, and cognitive needs. Clear document structures, readable formatting, captions for recorded presentations, accessible digital navigation, and compatibility with assistive technologies can improve

participation. These measures should be considered part of educational quality rather than optional accommodations.

Nevertheless, the availability of accessible materials does not automatically produce effective learning. Education is an active process requiring opportunities to ask questions, discuss uncertainty, receive feedback, and connect new knowledge with previous experience. Programmes based exclusively on the passive transmission of information may increase exposure to scientific content without necessarily strengthening critical thinking or professional competencies.

Opportunities for interaction are therefore essential. Discussion forums, virtual workshops, case-based seminars, peer-learning groups, and mentoring relationships can help learners interpret educational materials and explore how scientific principles apply to their own professional environments. These activities also encourage reciprocal exchange, allowing educators to understand the challenges encountered by participants and adapt future educational initiatives accordingly.

Mentorship can be particularly valuable for professionals who have limited access to established academic networks. Experienced clinicians, researchers, and educators can provide guidance on interpreting scientific literature, developing research questions, improving clinical practice, and navigating professional development opportunities. At the same time, mentoring should encourage independent judgment and recognize the expertise that participants bring from their own settings. The objective is not simply to transfer established knowledge, but to support the development of professionals capable of contributing actively to scientific discussion and healthcare improvement.

A sustainable educational model should also recognize that knowledge does not flow exclusively from highly resourced institutions to those with fewer resources. Healthcare professionals working in different environments develop practical solutions to challenges involving limited infrastructure, workforce shortages, restricted diagnostic capacity, and the need to prioritize essential services. These experiences can generate valuable insights into efficiency, adaptability, and the organization of care.

Reciprocal learning allows such insights to become part of a broader scientific and professional dialogue. When educational networks create opportunities for participants to share local experiences, question assumptions, and compare different approaches, knowledge becomes a collectively developed resource rather than a product transmitted from a single centre of authority.

This perspective is particularly relevant to global health because healthcare challenges are frequently shared, even when the resources available to address them differ. Infection prevention and control, antimicrobial resistance, access to essential surgery, patient safety, emergency preparedness, and the sustainability of healthcare services concern professionals across countries

and economic settings. International education can establish common scientific foundations while allowing participants to explore different practical responses to these challenges.

The relationship between education and implementation deserves particular attention. Acquiring information is only the first step in the process of improving healthcare. Knowledge must be interpreted, translated into appropriate decisions, and incorporated into clinical and organizational practices. This progression may require changes in professional behaviour, institutional procedures, resource allocation, and interdisciplinary collaboration.

Educational initiatives should therefore encourage participants to identify practical objectives that can be pursued within their own institutions. These may include improving recognition of clinical deterioration, strengthening infection prevention practices, promoting appropriate antimicrobial use, improving communication among healthcare teams, or introducing simple approaches to monitoring quality and safety. The feasibility of these activities depends on local circumstances, and educational programmes should avoid presenting complex interventions as universally applicable without considering the resources necessary for implementation.

Learning activities can become more valuable when they include opportunities to discuss barriers, identify realistic solutions, and evaluate whether proposed changes have been achieved. This approach connects education with quality improvement and encourages professionals to view scientific knowledge as a resource for continuous reflection and practical action.

Evaluation of educational programmes should consequently extend beyond participation numbers, downloads, certificates, or attendance at online sessions. These indicators can describe the reach of an initiative, but they provide limited information about its educational effectiveness. More meaningful evaluation may consider improvements in knowledge, critical reasoning, professional confidence, practical competencies, and the ability to apply evidence appropriately.

Where feasible, longer-term evaluation can examine whether educational activities contribute to changes in professional practice, institutional capacity, or healthcare processes. Such outcomes are influenced by multiple factors and should not automatically be attributed to education alone. Nevertheless, examining the relationship between learning and implementation can help institutions understand which educational approaches are most useful and how programmes might be improved.

Importantly, learners should participate in defining educational priorities and evaluating the relevance of the resources provided. A programme developed without consultation may address topics considered important by its organizers while overlooking the most immediate needs of participating professionals. Regular feedback, local participation in curriculum development, and opportunities to propose new educational activities can strengthen ownership and improve the responsiveness of international networks.

The long-term sustainability of educational cooperation also depends on institutional commitment. Open-access resources require scientific review, maintenance, updating, and technical support. Mentoring programmes require time and continuity. Multilingual activities require coordination and professional contributions. International partnerships must therefore recognize that equitable education, although often made freely available to learners, is not without cost and requires sustained organizational investment.

Such investment should be understood as part of strengthening healthcare systems rather than as an isolated educational expense. Professionals who have access to reliable knowledge, opportunities for critical discussion, and continued professional development are better positioned to contribute to safe and effective healthcare. Institutions that support learning can also strengthen their capacity to respond to emerging evidence, changing patient needs, and new public health challenges.

The ultimate objective of a borderless educational approach is not to create a single model of professional training for every country. It is to establish a shared commitment to scientific quality, equitable access, mutual learning, and the responsible application of knowledge. Educational systems should respect differences in professional roles, institutional resources, and local priorities while promoting common principles of evidence-based practice, patient safety, and continuous improvement.

In this perspective, education becomes both a means of strengthening individual competencies and a mechanism for building relationships across healthcare systems. Shared learning creates opportunities for professional dialogue, supports the development of trust, and encourages collaboration between people who may work in very different environments but share similar commitments to improving health.

The value of scientific knowledge is not determined solely by its production or availability, but by the opportunities it creates for people to understand, critically evaluate, adapt, and use it responsibly.

A genuinely borderless approach to global health education therefore requires more than removing financial or geographical barriers. It demands attention to scientific reliability, linguistic inclusion, technological accessibility, educational relevance, and the institutional conditions that allow learning to influence practice.

When these principles are combined, knowledge sharing can become a sustainable instrument of global health cooperation. It can support professional development, strengthen local capacity, encourage innovation, and facilitate the translation of scientific evidence into meaningful improvements in healthcare.

Ultimately, knowledge becomes a powerful shared resource when access is accompanied by understanding, understanding by critical reflection, and learning by the capacity to act. By making education more accessible, inclusive, and relevant to different healthcare realities, international cooperation can help transform scientific knowledge into a collective foundation for more equitable, resilient, and sustainable health systems.

Learning with rather than delivering to

Equitable global health education should be based on learning together rather than transferring knowledge from more privileged institutions to less-resourced settings. Educational programmes must be developed with the active participation of the professionals and communities they serve, ensuring that their priorities, practical challenges, and experiences influence what is taught and how learning is evaluated.

Healthcare systems differ in infrastructure, workforce, disease burden, and available resources. Consequently, educational approaches that work in highly specialized institutions may not be suitable for district hospitals, rural facilities, or resource-limited settings. Effective curricula should combine shared scientific principles with the flexibility needed to adapt their implementation to local circumstances, without compromising scientific rigor or patient safety.

Knowledge and expertise are not exclusive to wealthy institutions. Academic centres may contribute advanced research methods, technology, and specialized knowledge, while professionals working with limited resources often develop valuable expertise in clinical prioritization, teamwork, efficient organization, and practical problem-solving. These experiences can provide important lessons for all healthcare systems, including those with greater resources. This reciprocal exchange can encourage *frugal innovation*: developing effective, affordable, and sustainable solutions without treating resource limitations as acceptable substitutes for essential healthcare investment.

Equitable education therefore requires co-production rather than one-way knowledge transfer. Professionals from different countries, disciplines, and institutional settings should participate in identifying educational needs, developing curricula, teaching, evaluating results, and making strategic decisions. Their contributions must receive appropriate scientific recognition, authorship, and opportunities for leadership. Genuine inclusion means sharing responsibility and decision-making, not merely increasing the geographical diversity of invited speakers.

Mentorship should follow the same principle of reciprocity. Experienced researchers can provide scientific and methodological guidance, while frontline professionals contribute practical implementation experience and younger generations introduce new perspectives and digital

competencies. Structured mentoring can strengthen these exchanges and create opportunities for professional development and future leadership.

Meaningful participation also requires addressing practical barriers, including limited funding, heavy clinical workloads, inadequate technological access, and restricted opportunities for international collaboration. Flexible educational formats, remote participation, and institutional support can help make educational partnerships more accessible.

Finally, the success of educational programmes should be measured not only by participation or knowledge acquisition, but also by their ability to improve professional practice and healthcare delivery. Evaluation should consider local priorities, practical implementation, interdisciplinary collaboration, and measurable improvements, using feedback to refine educational activities over time.

Ultimately, equitable global health education means recognizing that every healthcare system has something to teach and something to learn. By combining scientific evidence, practical experience, shared leadership, and local ownership, international education can move beyond the simple transmission of information to become a collaborative process that strengthens healthcare systems, reduces inequalities, and translates knowledge into sustainable improvements in patient care.

Competence, not attendance, as the outcome

It is easy to report participant numbers or webinar views. Better evaluation asks whether learners can interpret evidence, recognize uncertainty, adapt recommendations and cooperate across professions. Short simulations, applied cases, supervised projects and follow-up audits offer more meaningful evidence than attendance certificates alone.

Competence is best assessed using tasks that resemble real decisions. A course on antimicrobial stewardship might ask learners to interpret an antibiotic prescription in light of severity, diagnostic uncertainty and local resistance patterns. A course on emergency response might assess the ability to identify a deteriorating patient and communicate across professional roles. Immediate test scores should be complemented by evidence of sustained application. When feasible, programmes should involve local mentors who can observe practice and help troubleshoot constraints after formal teaching ends.

A practical educational pathway may progress from introductory literacy to professional competence, then local leadership and mentoring. Every stage should produce an artifact. a teaching resource, quality-improvement project, surveillance plan or patient-safety intervention. Such products can be revised by peer networks and openly shared when privacy and intellectual-property rules permit.

Linking education, collaboration and local action

Education, collaboration, capacity development, and implementation are closely interconnected components of an effective global health strategy. Each contributes to a different dimension of healthcare improvement, but their greatest value emerges when they operate as part of a continuous and mutually reinforcing process. Education provides the scientific foundation for informed decisions, collaboration facilitates the exchange of professional experience, capacity development strengthens the ability of individuals and institutions to act, and implementation translates acquired knowledge into practical improvements in clinical care, healthcare organization, and community health.

The relationship between these elements is particularly important in a global health environment characterized by substantial differences in resources, professional competencies, institutional structures, and population needs. Scientific knowledge may be internationally relevant, but its practical application depends on the conditions in which healthcare professionals operate. The challenge is therefore not simply to make knowledge available, but to create the educational, organizational, and institutional conditions that allow it to be used appropriately and effectively.

Education represents the starting point of this process. High-quality educational initiatives should provide accurate, understandable, scientifically reliable, and applicable knowledge. Their purpose extends beyond the transmission of information to include the development of critical thinking, clinical reasoning, professional judgment, and the ability to interpret scientific evidence in relation to specific healthcare challenges. Learners should understand not only what is recommended, but also why a particular approach is supported, where uncertainty remains, and which factors may influence its applicability.

However, knowledge acquisition alone does not guarantee improvements in healthcare. Professionals may be familiar with evidence-based recommendations while lacking the resources, institutional support, or organizational authority required to implement them. Educational programmes that do not consider these practical limitations risk creating a gap between what healthcare workers know and what they can realistically achieve.

Collaboration helps bridge this gap by connecting scientific knowledge with the experience of professionals working in different environments. International and interdisciplinary exchanges provide opportunities to compare clinical practices, discuss organizational challenges, and examine how similar health problems are addressed under different circumstances. Such interactions can reveal assumptions that may remain unquestioned within individual institutions and encourage a more flexible and critical understanding of healthcare delivery.

The exchange of experience is particularly valuable when it involves professionals from different disciplines and levels of healthcare. Physicians, nurses, pharmacists, laboratory scientists,

epidemiologists, public health practitioners, and other members of the healthcare workforce contribute complementary perspectives to the identification and management of health challenges. Their collaboration can improve communication, clarify responsibilities, and support more comprehensive approaches to patient care and public health.

International cooperation also allows professionals to recognize that effective solutions do not necessarily originate in the most technologically advanced or financially resourced institutions. Healthcare services operating under constrained conditions may develop valuable approaches to prioritization, teamwork, resource allocation, and the organization of essential care. These experiences can offer practical lessons to institutions facing different but related challenges, reinforcing the principle that knowledge exchange should be reciprocal rather than unidirectional.

Capacity development provides the essential connection between learning and action. It involves strengthening the competencies, resources, institutional structures, and decision-making authority required to introduce and sustain improvements. Although education contributes to individual professional development, capacity building must also address the organizational conditions that determine whether acquired knowledge can be translated into practice.

For example, improving infection prevention and control requires more than teaching healthcare professionals the principles of hand hygiene, environmental cleaning, or surveillance. Effective implementation also depends on the availability of essential supplies, appropriate infrastructure, clear institutional responsibilities, adequate staffing, and mechanisms for monitoring adherence. Similarly, antimicrobial stewardship initiatives require not only education on appropriate prescribing but also organizational support, access to relevant diagnostic information, and opportunities for multidisciplinary collaboration.

These examples illustrate why capacity development should not be measured exclusively through knowledge, confidence, or participation in educational activities. Meaningful capacity exists when professionals and institutions possess the practical means and authority to apply what they have learned. It also requires the ability to identify emerging problems, adapt interventions, and maintain improvements over time.

Local leadership is therefore a fundamental element of capacity development. Healthcare professionals working within a particular institution or community often have the clearest understanding of its priorities, limitations, and opportunities for improvement. Their participation in planning and decision-making increases the likelihood that interventions will be appropriate, feasible, and sustainable.

International partnerships should support this leadership rather than replace it. External expertise, scientific resources, and technical assistance can be valuable, but their long-term contribution is greatest when they strengthen local autonomy and institutional competence. The objective

should be to develop the capacity of participating institutions to identify problems, evaluate evidence, make informed decisions, and implement improvements without remaining permanently dependent on external direction.

Implementation represents the practical expression of this integrated approach. It involves applying scientific knowledge and shared professional experience to priorities identified within clinical services, healthcare institutions, or communities. These priorities may include improving patient safety, strengthening infection prevention programmes, promoting responsible antimicrobial use, enhancing access to essential care, or developing more effective organizational processes.

Successful implementation requires attention to context. An intervention supported by scientific evidence may be appropriate in principle but difficult to introduce without adaptation to local resources, workforce competencies, institutional structures, and population needs. A strategy developed in a highly specialized academic centre cannot always be transferred unchanged to a district hospital or community healthcare service.

Adaptation, however, should not be confused with compromising scientific rigor or accepting inadequate standards of care. It involves identifying the essential principles of an intervention and determining how they can be applied safely and effectively under different circumstances. International collaboration can facilitate this process by allowing professionals to discuss practical barriers, compare experiences, and identify approaches that have proved useful in comparable settings.

Implementation also requires clearly defined objectives and realistic expectations. Educational and collaborative initiatives are more likely to produce meaningful results when participants identify specific problems, establish achievable priorities, determine the resources required, and agree on how progress will be assessed. This approach helps connect broad scientific principles with concrete actions that can be introduced into routine healthcare practice.

The process should remain flexible and responsive to experience. Not every intervention will achieve its intended objectives, and even scientifically well-supported strategies may encounter unexpected difficulties. Organizational resistance, resource limitations, competing priorities, or unforeseen consequences can influence outcomes. Recognizing these challenges is essential for improving future implementation efforts.

Figure 2 illustrates the process through which scientific evidence and education can be translated into practical, measurable, and sustainable improvements in healthcare. Education is an essential starting point, but knowledge alone does not automatically lead to changes in clinical practice or better patient outcomes. Effective implementation requires a structured approach that connects

scientific evidence with local needs, available resources, organizational capacity, and continuous evaluation.

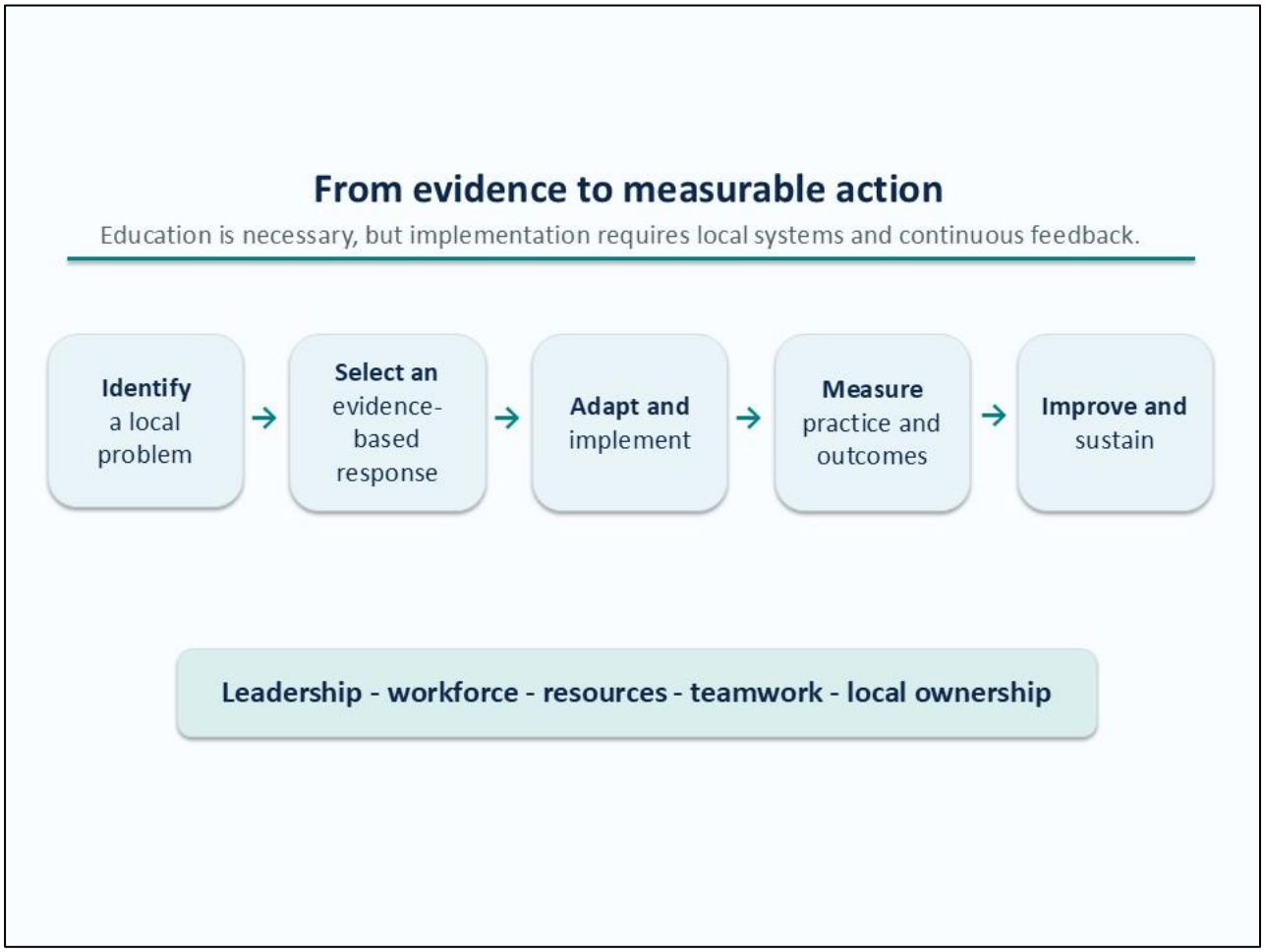


Figure 2. From evidence to measurable action

Both successful and unsuccessful experiences can generate valuable knowledge. Successful interventions may demonstrate which organizational conditions, educational approaches, or collaborative strategies facilitate change. Unsuccessful initiatives may reveal limitations in planning, unrealistic assumptions, insufficient resources, or a lack of alignment with local priorities. When these experiences are examined transparently, they contribute to collective learning and help prevent the repetition of avoidable mistakes.

This continuous relationship between education and implementation creates a feedback process in which practice informs future learning. Educational activities provide the knowledge required to introduce change, while implementation generates practical evidence about feasibility, acceptability, effectiveness, and sustainability. The lessons obtained can subsequently guide new

educational priorities, stimulate further collaboration, and identify additional capacity-building needs.

In this way, education, collaboration, capacity development, and implementation should not be understood as isolated activities or as a rigid sequence with a definitive endpoint. They form a dynamic process of continuous improvement in which knowledge and practice evolve together.

Integrating these dimensions also addresses two common weaknesses of international educational initiatives. The first is the dissemination of information without sufficient consideration of whether it leads to changes in professional practice. Conferences, webinars, educational manuals, and scientific publications can reach large audiences, but their availability does not necessarily translate into improved healthcare delivery.

The second weakness is the introduction of activities or interventions without meaningful evaluation. Programmes may generate considerable professional engagement and institutional visibility while providing limited evidence of their practical effects. Without appropriate evaluation, it becomes difficult to determine whether objectives have been achieved, whether resources have been used effectively, or whether interventions should be maintained, modified, or discontinued.

A more integrated approach encourages institutions to connect educational objectives with practical outcomes from the beginning. This does not mean that every educational activity must demonstrate an immediate measurable effect on patient outcomes. Learning, professional development, and organizational change often require time, and their consequences may be influenced by multiple factors. Nevertheless, educational initiatives should establish reasonable expectations regarding the competencies, practices, or institutional capacities they aim to strengthen.

Evaluation should therefore consider several dimensions, including knowledge acquisition, professional competencies, participant engagement, practical implementation, organizational change, and, where appropriate, healthcare processes and outcomes. The methods used should be proportionate to the objectives and resources of the programme, avoiding unnecessary complexity while preserving scientific credibility.

Importantly, evaluation should involve the professionals and institutions responsible for implementing change. Local participants should contribute to defining meaningful indicators, interpreting results, and identifying opportunities for improvement. This participatory approach strengthens ownership and helps ensure that evaluation remains relevant to the circumstances in which interventions take place.

The integration of education and implementation also creates valuable opportunities for students and early-career professionals. Their involvement should extend beyond attendance at lectures or participation in scientific meetings. They can contribute to identifying educational needs,

developing collaborative projects, reviewing evidence, collecting and interpreting data, and evaluating practical interventions.

Such experiences allow younger professionals to develop competencies that are essential for future healthcare leadership. These include critical thinking, teamwork, communication, project planning, scientific interpretation, problem-solving, and the ability to work across professional and institutional boundaries.

Structured mentorship can support this development by connecting early-career participants with experienced professionals who can provide methodological guidance, practical advice, and opportunities for increasing responsibility. At the same time, younger professionals can contribute new perspectives, technological competencies, and innovative approaches to education and collaboration.

Mentorship should therefore be understood as part of a broader process of professional and institutional renewal. By involving younger generations in practical projects and decision-making, international networks can help ensure the continuity of collaborative activities while preparing future leaders capable of integrating scientific evidence with the realities of healthcare delivery.

Intergenerational collaboration is especially important for the sustainability of international partnerships. Initiatives that depend exclusively on established leaders may lose momentum when institutional roles or professional circumstances change. Developing shared responsibilities and creating opportunities for emerging professionals to contribute can strengthen continuity and reduce dependence on individual personalities.

The connection between education and local action also requires institutional commitment. Healthcare professionals may be motivated to introduce improvements, but their efforts can remain limited without protected time, appropriate resources, administrative support, and recognition from institutional leadership. Sustainable implementation therefore depends on organizations that value continuous learning and create conditions in which professionals can apply new knowledge.

Institutional support is particularly important when interventions require changes in established routines or collaboration among different professional groups. Shared leadership, clear responsibilities, effective communication, and opportunities for feedback can help transform individual educational achievements into collective improvements.

At the same time, implementation should remain sensitive to the priorities of patients and communities. Healthcare improvements are meaningful when they respond to real needs and contribute to accessible, safe, effective, and equitable services. Community participation can help identify barriers that may not be apparent to healthcare institutions and can provide important perspectives on the acceptability and relevance of proposed interventions.

A borderless approach to global health should therefore connect international scientific collaboration with locally defined priorities. Global knowledge can provide guidance and shared standards, but the identification of practical objectives must remain responsive to the circumstances of the populations and institutions involved.

This relationship is especially important in settings where resources are limited. Educational initiatives should avoid creating expectations that cannot realistically be met without additional investments in infrastructure, workforce development, or essential services. Instead, collaboration should help distinguish between improvements that can be pursued through existing resources and those that require broader institutional or financial support.

Recognizing these differences allows international cooperation to remain both ambitious and realistic. It encourages the responsible adaptation of evidence while acknowledging that some barriers cannot be overcome through education or individual professional commitment alone.

The long-term objective is to strengthen the ability of healthcare systems to learn, adapt, and improve continuously. This requires not only the acquisition of new knowledge but also the development of institutional environments that support critical reflection, interdisciplinary collaboration, practical innovation, and the evaluation of outcomes.

When education is connected to implementation, scientific knowledge becomes more than a collection of recommendations. It becomes a resource that professionals and institutions can use to examine existing practices, identify opportunities for improvement, and introduce changes that respond to the needs of patients and communities.

Similarly, collaboration becomes more meaningful when it leads to shared problem-solving and practical learning. International networks should not be judged solely by their geographical reach or scientific visibility, but also by their capacity to strengthen local competencies, support institutional development, and facilitate sustainable improvements.

The central objective is not simply to transfer knowledge across borders, but to create the conditions in which knowledge can be understood, adapted, applied, evaluated, and continuously improved.

Education provides the foundation, collaboration enriches understanding, capacity development enables action, and implementation generates the experience necessary for further learning. Together, these elements create a continuous process through which scientific evidence and professional experience can contribute to stronger healthcare systems.

Ultimately, linking education, collaboration, and local action transforms international cooperation from an exchange of information into a shared commitment to practical improvement. Its value lies in empowering healthcare professionals, strengthening institutions, encouraging future

leadership, and ensuring that scientific knowledge contributes to meaningful and sustainable progress.

Global health cooperation becomes truly effective when shared knowledge strengthens local capacity, local action generates new learning, and that learning is returned to the wider international community for the benefit of all.

Key messages

- Equitable education requires accessible formats, relevant languages, protected learning time and attention to local barriers.
- Design educational initiatives with participating professionals and communities, recognizing expertise in every setting.
- Measure applied competence and changes in practice rather than registrations or certificates alone.
- Link learning to mentorship, collaborative problem-solving and locally owned improvement projects.

6
Infectious threats, prevention and antimicrobial resistance

Prevention protects the foundations of treatment

Infectious diseases remain one of the most important challenges for global health, demonstrating the close relationship between scientific progress, public health policies, and the capacity of healthcare systems to provide effective services. Advances in microbiology, diagnostic technologies, vaccines, and antimicrobial treatments have significantly improved the prevention and management of many infectious diseases. However, these scientific achievements can produce meaningful benefits only when they are supported by accessible healthcare services, effective prevention programmes, and reliable public health infrastructure.

The prevention and control of infectious diseases require a coordinated approach involving several components of the healthcare system. Early recognition of emerging threats depends on effective epidemiological surveillance, timely reporting of suspected cases, accessible diagnostic services, and the capacity to identify changes in disease patterns. Once a potential threat has been recognized, an effective response requires close cooperation between public health authorities, laboratories, healthcare professionals, and local communities.

Surveillance systems play a particularly important role because they allow health authorities to identify unusual increases in disease incidence, monitor the geographical distribution of infections, and detect potential outbreaks before they become more difficult to control. Their effectiveness depends not only on technological infrastructure but also on the availability of trained personnel, standardized reporting procedures, reliable laboratory services, and the willingness of healthcare institutions to share information promptly.

In an increasingly interconnected world, the importance of surveillance extends beyond national borders. International travel, population movements, trade, and environmental changes can influence the emergence and spread of infectious diseases. Consequently, delays in recognizing or communicating an infectious threat in one region may have consequences for populations elsewhere. International cooperation and timely exchange of epidemiological information are therefore essential for strengthening preparedness and supporting coordinated public health responses [24].

Nevertheless, surveillance alone cannot prevent infectious diseases. Effective prevention also requires vaccination programmes, safe drinking water, adequate sanitation, appropriate waste

management, food safety, infection prevention and control measures, and timely access to healthcare. These interventions address different mechanisms of disease transmission and should be considered complementary components of a comprehensive prevention strategy.

Vaccination represents one of the most effective public health interventions for reducing the burden of vaccine-preventable infectious diseases. Its benefits extend beyond individual protection because sufficiently high vaccination coverage can reduce transmission and protect vulnerable populations. However, successful immunization programmes depend on reliable vaccine supply chains, trained healthcare professionals, appropriate storage conditions, accessible vaccination services, and public confidence in the safety and effectiveness of vaccines.

Similarly, access to clean water and adequate sanitation remains fundamental for preventing infections associated with contaminated water, poor hygiene, and unsafe environmental conditions. Communities without reliable water supplies or sanitation infrastructure may face recurrent infectious disease outbreaks, even when effective diagnostic tools and treatments are available. Investments in water, sanitation, and hygiene therefore contribute directly to health protection while also supporting broader social and economic development.

These examples demonstrate that scientific innovation and basic public health infrastructure must advance together. The development of a new diagnostic test, vaccine, or antimicrobial treatment is valuable, but its impact may remain limited if health systems cannot ensure equitable access or deliver the intervention effectively. No medical innovation can fully compensate for the absence of essential prevention services or the deterioration of fundamental public health infrastructure.

A major challenge is that the benefits of prevention are often less visible than those of treatment. When an infection is successfully treated, the clinical benefit can frequently be observed directly. In contrast, successful preventive measures reduce the number of infections, complications, and deaths that would otherwise have occurred. Because these events are avoided, the value of prevention may be underestimated by policymakers, healthcare institutions, and the general public. This difference in visibility can influence healthcare priorities and the allocation of financial resources. During an infectious disease outbreak, substantial attention is directed toward emergency treatment, hospital capacity, diagnostic testing, and the availability of essential medicines. Although these measures are necessary, their effectiveness depends on prevention systems that should already have been established and maintained before the emergency.

Preparedness cannot be developed entirely after an outbreak has begun. Reliable surveillance networks, trained public health professionals, functioning laboratories, vaccination services, and infection prevention programmes require continuous investment and regular evaluation. Their maintenance is essential even during periods when infectious disease threats appear less urgent.

The experience of recent global health emergencies has illustrated how weaknesses in prevention and preparedness can rapidly affect healthcare delivery. Shortages of personal protective equipment, inadequate laboratory capacity, insufficient healthcare staffing, and difficulties coordinating public health responses may limit the ability of health systems to manage increasing demand. These challenges also demonstrate that preparedness is not simply the availability of emergency plans, but the practical ability to implement them under difficult conditions.

Effective prevention therefore requires long-term institutional commitment. Governments and healthcare organizations should establish stable financing mechanisms, maintain essential supplies, provide continuous professional education, and periodically assess their capacity to respond to infectious threats. Simulation exercises, surveillance audits, and evaluations of healthcare-associated infections can help identify weaknesses before they contribute to avoidable harm.

Within healthcare facilities, infection prevention and control (IPC) represents a fundamental component of patient safety and healthcare quality. Healthcare-associated infections can complicate medical and surgical treatment, prolong hospitalization, increase healthcare costs, and contribute to antimicrobial resistance. Preventing these infections requires an organized approach that integrates evidence-based practices into everyday clinical activities.

IPC should not be considered a separate activity performed only by infection control specialists or a set of procedures introduced during outbreaks. It should instead be embedded in the organization of healthcare services and supported by institutional leadership, multidisciplinary collaboration, appropriate infrastructure, and continuous education.

Hand hygiene is a central component of infection prevention, but its effectiveness depends on more than the knowledge of recommended procedures. Healthcare professionals must have convenient access to hand hygiene products, adequate facilities, sufficient time, and a working environment that supports safe practices. When compliance is inadequate, the underlying causes should be investigated rather than assuming that the problem results exclusively from individual behaviour.

Environmental cleaning and disinfection are equally important, particularly in areas where vulnerable patients receive care. Effective programmes require clearly defined responsibilities, appropriate cleaning products, trained personnel, and procedures adapted to the risks associated with different healthcare environments. Environmental services staff should be recognized as essential contributors to infection prevention and included in relevant training and quality improvement activities.

Safe invasive procedures represent another priority. The insertion and management of vascular catheters, urinary catheters, and other medical devices can expose patients to infection when appropriate precautions are not followed. Prevention strategies should include careful

assessment of the indication for each device, aseptic insertion techniques, appropriate maintenance, regular reassessment of clinical necessity, and prompt removal when the device is no longer required.

In surgical care, infection prevention requires coordination throughout the perioperative pathway. Appropriate patient preparation, surgical hand antisepsis, sterile technique, correct antimicrobial prophylaxis when indicated, and careful postoperative monitoring all contribute to reducing the risk of surgical site infections. These measures are most effective when implemented as part of a coordinated programme supported by training, monitoring, and regular feedback to clinical teams.

Importantly, infection prevention cannot depend exclusively on the efforts of individual healthcare workers. Organizational conditions strongly influence the ability to follow recommended practices. Excessive workloads, inadequate staffing, overcrowding, interruptions in the supply of essential materials, and poorly designed clinical environments may undermine even well-established prevention programmes.

Healthcare institutions should therefore evaluate both adherence to recommended practices and the practical barriers that prevent their implementation. Monitoring systems are most useful when they help professionals understand why problems occur and identify feasible solutions. For example, low hand hygiene compliance may reflect inadequate placement of dispensers, while inconsistent device review may result from unclear responsibilities during clinical handovers.

A constructive approach to IPC combines clear professional accountability with institutional support. Healthcare workers should receive appropriate training and feedback, while leadership should ensure that the necessary resources and organizational conditions are available. Infection prevention is more likely to become sustainable when it is integrated into routine clinical governance, quality improvement programmes, and patient safety strategies.

Surveillance of healthcare-associated infections also provides important information for evaluating prevention programmes. However, collecting data is not sufficient unless results are analyzed, communicated to clinical teams, and used to guide improvements. Surveillance should be adapted to the diagnostic and organizational capacities of individual facilities while maintaining appropriate standards of accuracy and consistency.

This consideration is especially relevant in healthcare settings with limited resources. Hospitals may face difficulties implementing comprehensive surveillance systems because of inadequate laboratory services, shortages of trained personnel, or limited digital infrastructure. In such circumstances, prevention programmes should prioritize feasible interventions with clear clinical value while progressively strengthening the capacity to collect and interpret reliable data.

International cooperation can contribute significantly to these efforts. Sharing scientific evidence, practical experience, educational resources, and implementation strategies can help healthcare institutions identify effective interventions and adapt them to local circumstances. However, the transfer of knowledge should not be understood as the simple replication of protocols developed in highly resourced settings. Sustainable improvement requires an understanding of local epidemiology, organizational constraints, available resources, and the priorities identified by healthcare professionals working directly with patients.

Prevention also has an important ethical and equity dimension. Patients should not face substantially greater risks of avoidable infections simply because they receive care in facilities with limited financial resources or inadequate infrastructure. Although healthcare systems differ considerably in their capacities, access to basic infection prevention measures should be recognized as an essential component of safe and equitable healthcare.

Strengthening infection prevention therefore contributes to several interconnected global health objectives. It protects patients and healthcare workers, reduces avoidable complications, supports responsible antimicrobial use, and improves the resilience of healthcare systems. It can also help preserve resources by reducing infections that require additional diagnostic investigations, prolonged hospitalization, or complex treatment.

Importantly, infectious disease prevention should be understood as a continuous responsibility rather than an emergency intervention. Scientific discoveries provide increasingly effective tools for protecting health, but their benefits depend on the ability of healthcare systems to implement preventive measures consistently and equitably. Investing in surveillance, vaccination, sanitation, infection prevention, professional education, and public health infrastructure is essential for reducing the burden of infectious diseases and improving preparedness for future threats.

A sustainable global health strategy must therefore give prevention the same importance as diagnosis and treatment. Strong prevention systems protect individuals, support essential healthcare services, and create the conditions in which scientific progress can translate into lasting improvements in population health.

Figure 3 illustrates how effective prevention depends on four interconnected components: surveillance, primary prevention, infection prevention and control (IPC) in healthcare settings, and implementation.

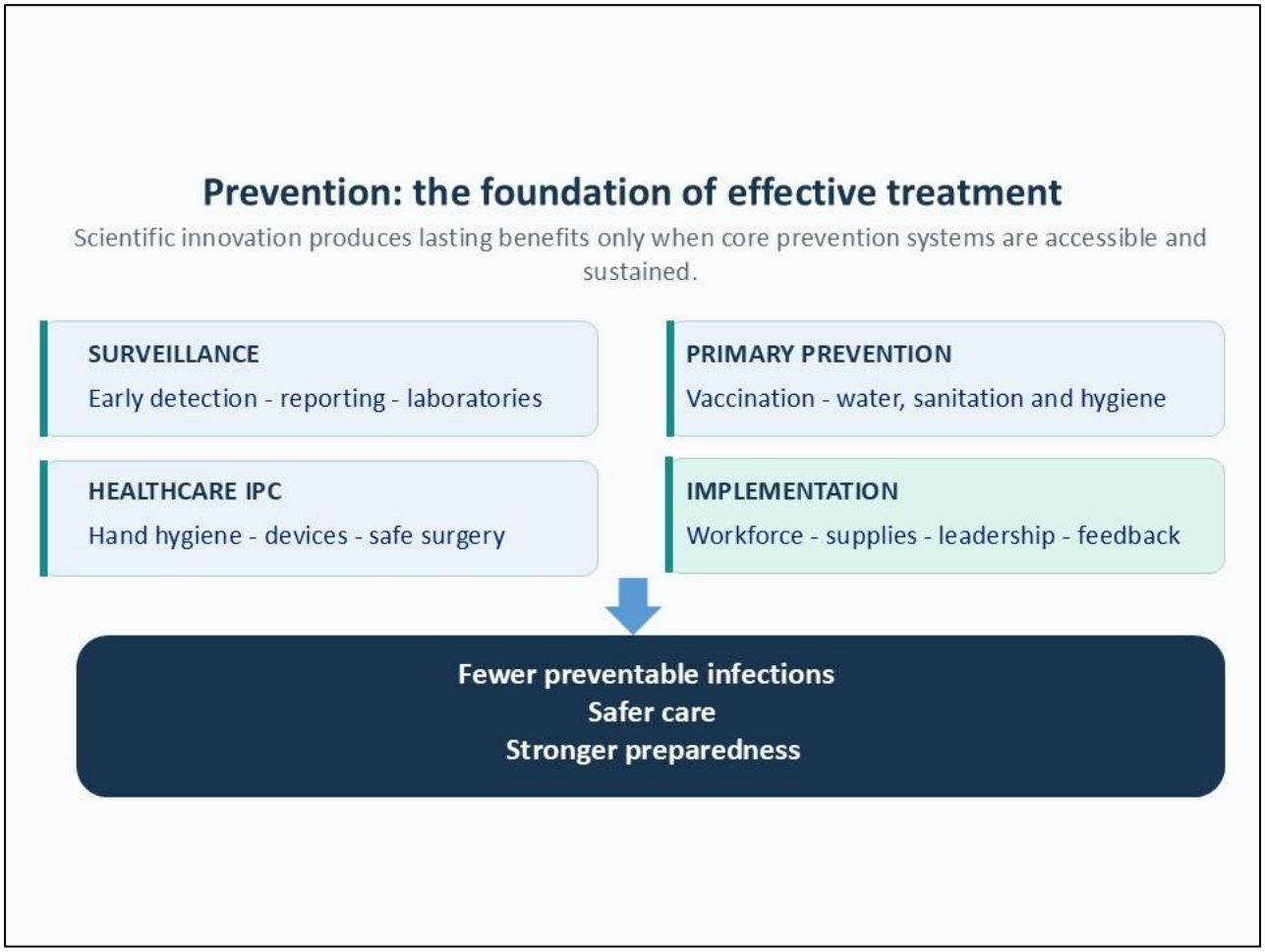


Figure 3. Prevention as the foundation of effective treatment and health-system resilience

Emerging and re-emerging infections: changing threats, enduring vulnerabilities

Emerging infectious diseases represent a major and continuously evolving challenge to global public health. They may arise as a consequence of the identification of previously unknown pathogens, the introduction of known infectious agents into new geographical areas or previously unaffected populations, or significant changes in the incidence, distribution, pathogenicity, or transmission dynamics of already recognized diseases. Re-emerging infectious diseases, in contrast, refer to infections that were previously under control, had substantially declined in incidence, or had become less prominent as public health concerns, but subsequently return or increase in frequency, severity, or geographical distribution. The distinction between emerging and re-emerging infections is not always clear-cut, since previously established pathogens may acquire new epidemiological characteristics and produce unexpected patterns of transmission under changing environmental, demographic, and social conditions [24, 25].

The re-emergence of measles in several settings illustrates how the interruption of vaccination programmes, declining vaccine confidence, population displacement, and inequalities in access to healthcare can rapidly restore transmission of a disease that is largely preventable through immunization. Similarly, cholera continues to pose a significant public health threat in areas characterized by inadequate access to safe drinking water, insufficient sanitation infrastructure, overcrowding, and humanitarian emergencies. Other infections, particularly vector-borne diseases, have demonstrated changes in their geographical distribution and seasonal patterns, partly reflecting modifications in temperature, precipitation, land use, urbanization, and the distribution of competent vectors. These examples highlight that the emergence and re-emergence of infectious diseases cannot be attributed exclusively to the biological properties of pathogens, but must be understood as the result of complex interactions between infectious agents, human populations, animal reservoirs, and environmental conditions [24, 25].

Several interconnected drivers contribute to the changing epidemiology of infectious diseases. Pathogen evolution, including genetic variation, mutation, and recombination, may facilitate the acquisition of new biological characteristics, potentially affecting transmissibility, host range, immune escape, or antimicrobial susceptibility. At the same time, demographic growth, population ageing, urban expansion, increased international travel, migration, and global trade create new opportunities for infectious agents to circulate and reach populations with limited previous exposure or immunity. Changes in human activities and in the interfaces between humans, domestic animals, wildlife, and their shared environments may further increase the likelihood of zoonotic spillover, particularly where agricultural intensification, deforestation, habitat fragmentation, and wildlife exploitation alter ecological relationships.

Environmental and climatic changes constitute additional determinants of infectious disease emergence. Variations in temperature and rainfall, extreme weather events, flooding, drought, and changes in ecosystem structure can influence pathogen survival, vector abundance, reservoir distribution, and patterns of human exposure. In particular, shifts in the geographical range and seasonal activity of mosquitoes, ticks, and other disease vectors may create conditions favourable to the establishment or expansion of infections in areas where transmission was previously limited or absent. These processes are not uniform and depend on the interaction between environmental suitability, local ecological characteristics, population immunity, and the availability of effective prevention and healthcare services.

Socioeconomic and political factors are equally important in shaping infectious disease vulnerability. Poverty, inadequate housing, malnutrition, limited access to clean water and sanitation, weak healthcare systems, political instability, armed conflicts, and forced displacement can increase exposure to pathogens while simultaneously reducing the capacity of communities to

prevent, detect, and respond to infections. Health inequalities may therefore contribute both to the initial emergence of an epidemic and to its subsequent persistence and geographical expansion. Furthermore, the inappropriate use of antimicrobial agents and the resulting selection of antimicrobial-resistant microorganisms represent an additional challenge, potentially compromising the effectiveness of established therapeutic strategies and increasing the burden associated with previously manageable infections. Taken together, these determinants demonstrate that infectious disease emergence is a multifactorial process requiring integrated approaches that consider human health, animal health, and environmental sustainability [24, 25].

Understanding the terminology used to describe infectious disease occurrence and transmission is essential for epidemiological surveillance, risk assessment, public health planning, and communication. The terms *endemic*, *epidemic*, *outbreak*, and *pandemic* describe different epidemiological patterns and should not be considered interchangeable. An endemic infection is one that is continuously present within a particular geographical area or population at an expected or relatively stable level of occurrence. Endemicity does not necessarily indicate low disease burden, limited clinical consequences, or an absence of public health concern. An endemic infection may continue to cause substantial morbidity and mortality, particularly among vulnerable populations, and may require sustained surveillance, vaccination, treatment, and other control measures.

An epidemic occurs when the number of cases of a disease exceeds the level normally expected within a defined population, geographical area, and period. The identification of an epidemic therefore depends on the availability of baseline epidemiological data and on the ability to recognize deviations from established patterns of disease occurrence. An outbreak is commonly used to describe a more localized increase in cases, often involving a specific institution, community, geographical area, or population group. Although the terms outbreak and epidemic are sometimes used interchangeably, the former generally emphasizes a more restricted epidemiological event. Both situations require timely investigation to identify the source of infection, characterize transmission pathways, determine the populations at risk, and implement appropriate control measures.

A pandemic refers to an epidemic that has spread across multiple countries or continents and affects large populations. Unlike the terms epidemic and outbreak, which may primarily emphasize increases in disease occurrence within defined settings, pandemic describes the extensive geographical distribution of an infectious disease. Importantly, the designation of a pandemic does not necessarily indicate a specific level of clinical severity, mortality, or individual risk. A pathogen may spread widely across international borders while producing different levels of morbidity and mortality according to population characteristics, immunity, healthcare capacity, environmental conditions, and access to preventive and therapeutic interventions.

These epidemiological categories are not mutually exclusive or necessarily sequential. The same infectious agent may circulate at endemic levels in one geographical area, cause localized outbreaks in another, and generate a large-scale epidemic or pandemic under favourable conditions for transmission. Moreover, the epidemiological status of an infection may evolve over time as a consequence of changes in population immunity, pathogen characteristics, environmental conditions, human mobility, and public health interventions. Following a pandemic, for example, an infectious disease may continue to circulate in a population and eventually establish a pattern of endemic transmission, although this transition does not imply the disappearance of its associated health burden.

The distinction between these terms has practical implications for public health decision-making. Accurate classification of disease occurrence supports the interpretation of surveillance data, the identification of unusual transmission patterns, the allocation of healthcare resources, and the development of proportionate prevention and control strategies. It also contributes to effective risk communication by helping policymakers, healthcare professionals, and the general population understand the nature, geographical extent, and potential consequences of an infectious disease threat. Ultimately, the capacity to recognize emerging and re-emerging infections, identify the factors driving their spread, and distinguish their different epidemiological patterns is fundamental to strengthening preparedness, improving early detection, and reducing the impact of infectious diseases at both national and global levels [25].

Pandemics through history: recurring lessons for global health

History provides repeated reminders that infectious threats have shaped societies well beyond their immediate health consequences. The Justinianic plague in the sixth century and the Black Death in the fourteenth century are among the most consequential historical plague pandemics. Successive cholera pandemics beginning in the nineteenth century exposed the importance of safe water, sanitation, urban conditions, and public health organization. Smallpox caused enormous mortality over centuries before global vaccination and international coordination made eradication possible. The 1918–1919 influenza A(H1N1) pandemic, commonly known as the Spanish flu, remains one of the most devastating infectious disease events in modern history. Emerging during the final year of the First World War, it spread rapidly across continents, facilitated by unprecedented movements of soldiers, overcrowded military camps, international transportation, and the difficult living conditions experienced by populations already weakened by years of conflict, food shortages, and social disruption. The geographical origin of the pandemic remains uncertain. Although the disease became widely known as the Spanish flu, there is no convincing evidence that it originated in Spain. The name largely reflected the fact that Spain, being neutral

during the war, had a relatively free press that openly reported the epidemic, while several countries involved in the conflict restricted information to maintain public morale [25, 26].

The pandemic developed through successive waves between the spring of 1918 and 1919. The first wave, observed in several regions during the spring of 1918, was generally less severe, although it spread rapidly through military and civilian populations. A second, much more lethal wave emerged in the autumn of 1918, causing extraordinary mortality across Europe, North America, Asia, Africa, and other regions. A third wave followed during the winter and spring of 1919. Historical estimates suggest that approximately 500 million people, nearly one-third of the world's population at that time, became infected, while at least 50 million died worldwide, although the true mortality remains uncertain because of incomplete surveillance and limited health records [25, 26].

The influenza pandemics of 1957 (H2N2), 1968 (H3N2), and 2009 (H1N1) illustrate the persistence of pandemic influenza risk. HIV/AIDS, recognized in the early 1980s, developed into a prolonged global pandemic that transformed infectious-disease care, community mobilization, research, and debates about equitable treatment access. The COVID-19 pandemic beginning in 2019 added a further lesson about the simultaneous vulnerability of health systems, supply chains, economies, and social trust. These episodes differ substantially in transmission, mortality, time course, and available interventions, and historical estimates are often uncertain. They should not be treated as interchangeable events. Their shared lesson is that effective response requires scientific knowledge alongside trust, equitable access, surveillance, public-health infrastructure, and sustained international cooperation [25, 26].

Ebola in the Democratic Republic of the Congo: the cost of fragmented action

Ebola illustrates both what coordinated response can achieve and what is at risk when cooperation, access, and resources remain insufficient. In the Kasai Province of the Democratic Republic of the Congo, an Ebola outbreak declared in September 2025 ended on 1 December 2025. WHO reported 64 confirmed and probable cases and 45 deaths; national authorities, WHO, UNICEF, and other partners supported surveillance, infection prevention, clinical response, vaccination where applicable, and community engagement [27]. This episode is important precisely because international cooperation helped interrupt transmission despite difficult local conditions.

A separate, much larger outbreak caused by Bundibugyo virus has been ongoing in the Democratic Republic of the Congo since May 2026, against a backdrop of insecurity, humanitarian needs, challenging access, and population movement. According to the European Centre for Disease Prevention and Control, as of 11 November 2026 the country had recorded 11,114 confirmed cases and 5,433 associated deaths, with ongoing community transmission across eight

provinces; these provisional surveillance figures may be revised [28]. Unlike Ebola outbreaks for which licensed Zaire ebolavirus vaccines and therapeutics can be used, the Bundibugyo outbreak lacks an approved vaccine or specific therapy, making timely detection, supportive care, infection prevention and control, contact tracing, community engagement, and rapid international research especially important [28].

It would be inaccurate to describe the 2026 outbreak as solely the consequence of a failure of international cooperation: insecurity, difficult terrain, health-system constraints, pathogen-specific limitations, and delayed detection all matter. Nevertheless, it is a powerful illustration of the consequences of inadequate collective capacity and the need for more reliable cross-border cooperation. Fragmented financing, slow sharing of information or materials, weak local trust, and obstacles to humanitarian access can create avoidable delays and additional deaths. A genuine global-health response must support locally led action and the continuous capacities needed to prevent an outbreak from becoming a prolonged regional emergency.

Antimicrobial Resistance as a natural phenomenon and a global health challenge

Antimicrobial resistance (AMR) represents one of the most important and complex challenges facing global health. It develops when microorganisms possess, acquire, or express mechanisms that reduce the effectiveness of antimicrobial agents, making infections more difficult to treat and increasing the risk of complications, prolonged illness, and death. Although often described as an emerging threat, AMR is not a new biological phenomenon, nor is it a process created by modern medicine. It is deeply rooted in the natural evolution of microorganisms and their continuous adaptation to environmental pressures.

AMR is a natural evolutionary phenomenon, but human activities have dramatically accelerated its selection, amplification, and dissemination. Resistance mechanisms existed in microbial ecosystems long before antibiotics were discovered and introduced into clinical practice. Microorganisms have evolved mechanisms to survive exposure to naturally occurring antimicrobial substances through genetic mutations, intrinsic protective characteristics, and the acquisition of resistance determinants from other microorganisms. These processes are part of microbial evolution and cannot be eliminated.

What has changed profoundly over the past century is the intensity and scale of selective pressure exerted by human activities. The widespread use of antimicrobial agents in human healthcare, veterinary medicine, agriculture, and animal production has created conditions that favour resistant microorganisms, allowing them to survive, multiply, and spread more rapidly. Environmental contamination, inadequate sanitation, insufficient infection prevention, and the

increasing movement of people, animals, and goods have further contributed to the dissemination of resistance across geographical and ecological boundaries.

The distinction between the natural origins of resistance and its human-driven acceleration is fundamental. It prevents an inaccurate interpretation of AMR as a phenomenon caused exclusively by inappropriate antibiotic prescribing, while emphasizing that many of the factors responsible for its current global impact are modifiable. The objective of AMR control is not to eliminate a natural evolutionary process, which is biologically impossible, but to reduce its avoidable acceleration and limit its consequences for human and animal health.

The development of resistance is closely associated with the selective pressure created by antimicrobial exposure. When antibiotics are administered, susceptible bacteria may be eliminated or inhibited, while organisms possessing effective resistance mechanisms may survive and multiply. Resistance genes can also be exchanged between bacteria through horizontal gene transfer, allowing resistance determinants to circulate across different bacterial species and environments. These processes demonstrate that AMR is influenced by biological evolution but also by human decisions and the organization of healthcare systems. The frequency, appropriateness, and duration of antimicrobial exposure influence selective pressure, while infection prevention practices, sanitation, healthcare infrastructure, and diagnostic capacity influence the opportunities for resistant microorganisms to spread.

Importantly, even appropriate antibiotic treatment can exert selective pressure. Responsible antimicrobial use can reduce unnecessary selection, but it cannot completely remove the evolutionary consequences of antimicrobial exposure. This is why antimicrobial stewardship must be integrated with effective infection prevention and control rather than considered an isolated prescribing intervention.

AMR should therefore not be understood exclusively as a consequence of individual prescribing decisions. It is a broader health systems challenge involving clinical practice, public health, pharmaceutical production, food systems, environmental management, and equitable access to essential healthcare services. The circulation of resistant microorganisms between hospitals, communities, animals, and the environment illustrate why AMR requires coordinated action across sectors and national boundaries.

The global burden of bacterial AMR demonstrates the seriousness of this challenge. A comprehensive analysis published in 2024 estimated that approximately 1.14 million deaths worldwide were attributable to bacterial AMR in 2021 [29, 30]. This estimate refers to deaths that might have been avoided if the infections had been caused by susceptible rather than resistant bacteria. It is important to distinguish deaths attributable to resistance from deaths associated with resistance, which include patients with resistant infections even when resistance itself was not

necessarily the determining cause of death. Communicating this distinction accurately is essential for understanding the burden of AMR and avoiding misleading interpretations of epidemiological estimates.

Beyond mortality, AMR has substantial consequences for healthcare delivery, patient safety, and health system sustainability. Resistant infections may require antimicrobial agents that are more expensive, less readily available, or associated with greater toxicity. Treatment can become more complex, require longer hospitalization or intravenous administration, and involve additional laboratory investigations and clinical monitoring. These consequences increase healthcare expenditure and place further pressure on systems that may already struggle with limited resources.

The impact of AMR extends across many areas of modern medicine. Effective antimicrobial therapy is essential for treating severe bacterial infections and supporting the safety of numerous medical and surgical interventions. Surgery, intensive care, organ transplantation, cancer treatment, and the management of patients with major trauma or severe immunosuppression all depend, to varying degrees, on the availability of effective antibiotics. Increasing resistance can compromise the prevention and treatment of infections in these settings, potentially affecting clinical outcomes and limiting therapeutic options.

However, the consequences of AMR are not equally distributed across countries and populations. Healthcare systems with limited laboratory capacity, restricted access to essential medicines, inadequate infection prevention infrastructure, or shortages of trained healthcare professionals may face particular difficulties in diagnosing and treating resistant infections. In some regions, patients experience significant delays before receiving effective antimicrobial therapy. In others, antibiotics may be prescribed without adequate microbiological evaluation because diagnostic services are unavailable or unaffordable.

These contrasting situations reveal a central ethical and practical challenge. Excessive or inappropriate antimicrobial use can accelerate the selection of resistant microorganisms, but inadequate access to necessary antibiotics can also cause preventable suffering and death. Reducing antimicrobial consumption without considering patient needs, disease severity, and healthcare inequalities may therefore produce unintended harm.

The objective should not simply be to use fewer antibiotics, but to ensure that antimicrobials are used appropriately, effectively, and equitably. Responsible use means avoiding unnecessary exposure while guaranteeing timely treatment for patients who genuinely need it.

Timely and accurate diagnosis is essential for achieving this balance. Clinical assessment, microbiological investigations, and appropriate diagnostic tests can help distinguish bacterial infections from conditions that do not benefit from antibiotic treatment. When a bacterial infection is

suspected, diagnostic information can also support the selection of an appropriate antimicrobial agent and help determine the necessary duration of treatment.

Microbiology laboratories play a particularly important role in the management of resistant infections. Identification of the causative microorganism and antimicrobial susceptibility testing can help clinicians select effective treatment, avoid unnecessary broad-spectrum antibiotic exposure, and recognize emerging resistance patterns. At institutional and national levels, microbiological data contribute to surveillance programmes and support the development of empiric treatment recommendations adapted to local epidemiology.

Nevertheless, microbiological investigations are not equally accessible in all healthcare settings. Some hospitals lack the equipment, trained personnel, laboratory supplies, or financial resources necessary to perform routine cultures and susceptibility testing. Even where laboratory services are available, delays in obtaining results may limit their immediate usefulness in critically ill patients.

In these circumstances, clinicians must often make treatment decisions based on clinical findings, disease severity, available epidemiological information, and local patterns of resistance. Such decisions should recognize diagnostic uncertainty while maintaining patient safety as the primary objective.

Strengthening microbiological capacity is therefore not only a technological priority but also an essential component of equitable healthcare. Reliable diagnostics can support better patient outcomes, reduce unnecessary antimicrobial exposure, and improve surveillance. At the same time, healthcare professionals working in resource-limited settings need practical, evidence-informed strategies that can be implemented while laboratory services are progressively strengthened.

The management of severe bacterial infections illustrates why antimicrobial stewardship must always be balanced with the need for timely and effective treatment. Patients with sepsis, septic shock, or other life-threatening infections may require prompt initiation of appropriate antimicrobial therapy. Delaying necessary treatment solely to reduce antibiotic consumption or await microbiological confirmation can expose patients to serious and avoidable risks.

Early treatment should, however, be followed by systematic clinical reassessment. Once additional diagnostic information becomes available, clinicians should evaluate whether antimicrobial treatment remains necessary, whether the selected agent remains appropriate, and whether the spectrum of activity can be narrowed. Treatment should also be reviewed in relation to the patient's clinical evolution, organ function, microbiological findings, and the adequacy of source control.

Antimicrobial stewardship is therefore best understood as a coordinated strategy to optimize antimicrobial treatment rather than merely restrict antibiotic prescriptions. Its purpose is to ensure

that patients receive the appropriate antimicrobial agent, at the correct dose, through the appropriate route, and for an evidence-informed duration, while minimizing avoidable toxicity, unnecessary exposure, and the selection of resistant microorganisms [31, 32].

Effective stewardship programmes require collaboration among clinicians, surgeons, pharmacists, microbiologists, infectious disease specialists, nurses, infection prevention professionals, and healthcare administrators. Each professional group contributes to different stages of antimicrobial management, from diagnosis and prescribing to drug administration, monitoring, reassessment, and surveillance.

A central component of stewardship is the development of evidence-based recommendations adapted to local epidemiology and available clinical resources. Empiric antimicrobial treatment should reflect the likely source of infection, the patient's clinical condition, previous antimicrobial exposure, individual risk factors for resistant pathogens, and available susceptibility data. A regimen that is appropriate in one healthcare institution may be less suitable in another where resistance patterns, diagnostic resources, or drug availability differ substantially.

Appropriate dosing is equally important. The effectiveness of antimicrobial treatment depends not only on selecting an active agent but also on achieving adequate drug exposure at the site of infection. Patient characteristics, organ function, severity of illness, and pharmacokinetic and pharmacodynamic properties may influence antimicrobial dosing. These considerations are particularly relevant in critically ill patients, in whom changes in fluid distribution and organ function can substantially alter drug concentrations and therapeutic effectiveness.

Stewardship also requires determining when antimicrobial treatment can be safely discontinued. Antibiotics are sometimes continued longer than necessary because of diagnostic uncertainty, concern about clinical deterioration, or the absence of structured reassessment procedures. Establishing regular opportunities to review ongoing treatment can help clinicians identify patients who no longer require antibiotics or who may safely receive shorter courses of therapy.

In infections requiring procedural intervention, antimicrobial treatment must be integrated with appropriate source control. Drainage of infected collections, removal of infected devices, debridement of nonviable tissue, and surgical management of an infectious focus may be essential for clinical resolution. Antibiotics alone may be insufficient when an uncontrolled source of infection persists. Effective treatment therefore requires coordinated decision-making among medical, surgical, and critical care teams.

Infection prevention and control is equally important in limiting the consequences and spread of AMR. Preventing infections reduces the need for antimicrobial treatment and decreases opportunities for resistant microorganisms to spread. Hand hygiene, environmental cleaning, safe management of invasive devices, appropriate isolation precautions, surveillance of healthcare-

associated infections, and the consistent application of evidence-based preventive measures are therefore indispensable complements to antimicrobial stewardship.

This relationship illustrates the fundamental principle that preventing infections is also a way of reducing antimicrobial selective pressure. A healthcare system that successfully decreases preventable infections can reduce antimicrobial exposure while improving patient safety. Conversely, a system that focuses exclusively on prescribing restrictions without strengthening infection prevention may fail to address important drivers of resistance.

Successful stewardship also depends on the organizational environment in which healthcare professionals work. Clinical guidelines are unlikely to produce sustainable improvements if essential antimicrobial agents are unavailable, diagnostic services are unreliable, or healthcare teams lack sufficient time and support to reassess treatment. Institutions should therefore identify the practical barriers that influence antimicrobial use and develop solutions that reflect their local circumstances.

Education and continuous professional development remain essential. Healthcare professionals need opportunities to update their understanding of AMR, interpret microbiological findings, apply principles of antibiotic selection and dosing, and translate evidence-based recommendations into daily clinical practice. Educational interventions are particularly useful when combined with practical case discussions, prescribing audits, feedback, and multidisciplinary review.

Monitoring antimicrobial use and resistance patterns provides further opportunities for improvement. Hospitals and public health institutions can use surveillance data to identify emerging threats, evaluate prescribing practices, and detect areas where targeted interventions may be beneficial. Surveillance, however, should not become an exercise in collecting information without translating it into decisions. Its value depends on the capacity to generate reliable evidence that informs prevention, treatment, resource allocation, and policy.

The global nature of AMR requires cooperation beyond individual healthcare institutions. Resistant microorganisms and resistance genes can spread through human mobility, healthcare-associated transmission, food production, environmental pathways, and international trade. National responses must therefore be connected to broader strategies involving human health, animal health, agriculture, pharmaceutical regulation, and environmental protection.

A One Health perspective is particularly relevant because antimicrobial use and resistance occur across interconnected human, animal, and environmental systems. Responsible antimicrobial practices in veterinary medicine, improved management of pharmaceutical and agricultural waste, environmental surveillance, and coordinated monitoring of resistance can complement interventions implemented in human healthcare.

International cooperation is essential, particularly where diagnostic capacity, research infrastructure, and access to effective antimicrobial agents remain limited. Sharing surveillance information, strengthening laboratory networks, supporting professional education, and facilitating equitable access to scientific knowledge can help countries develop locally appropriate responses.

Such cooperation should also recognize that valuable expertise is not confined to high-income settings. Healthcare professionals working with limited resources often develop practical strategies for prioritizing interventions, optimizing essential medicines, and organizing care under difficult conditions. These experiences can contribute to more efficient and sustainable approaches elsewhere. Global collaboration should therefore promote reciprocal learning rather than assume that knowledge flows exclusively from wealthier countries to those with fewer resources.

Ultimately, AMR illustrates the close relationship between natural biological evolution, human activity, healthcare organization, and global equity. Scientific progress, including the development of new antimicrobial agents and diagnostic technologies, remains essential. Yet innovation alone cannot solve the problem if healthcare systems are unable to use these technologies appropriately or ensure access for patients who need them.

An effective global response must pursue two complementary objectives. First, it must reduce avoidable selective pressure and prevent the unnecessary transmission of resistant microorganisms. Second, it must protect timely and equitable access to effective antimicrobial treatment for patients with serious infections.

Achieving this balance requires reliable diagnostics, appropriate prescribing, infection prevention, effective source control, surveillance, professional education, sustainable healthcare infrastructure, and sustained international cooperation.

AMR cannot be eradicated because it is an intrinsic feature of microbial evolution. However, its human-driven acceleration can be limited through responsible decisions, effective prevention, and coordinated action.

Addressing AMR is therefore not simply a matter of controlling antibiotic consumption. It represents a broader commitment to improving the quality, safety, sustainability, and equity of healthcare while preserving the effectiveness of antimicrobial treatment for present and future generations.

Figure 4 illustrates the interaction between natural evolutionary mechanisms and human activities in the emergence, selection, and dissemination of AMR.

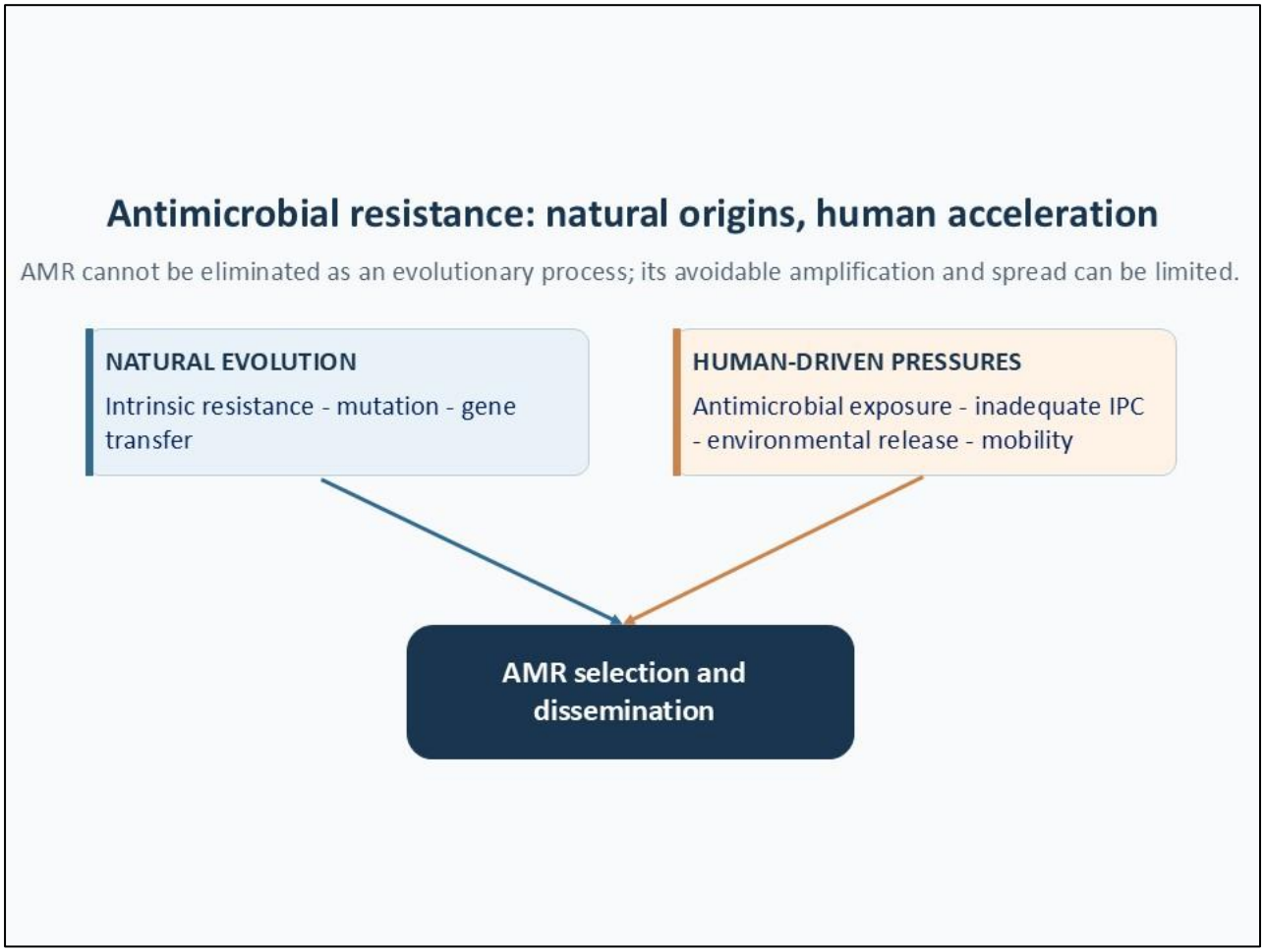


Figure 4. Antimicrobial resistance: natural origins and human-driven acceleration

An implementation approach across settings

The successful implementation of antimicrobial stewardship programmes requires a practical approach adapted to the needs, priorities, and available resources of each healthcare institution. Hospitals should begin by identifying their most important challenges related to infectious diseases and antimicrobial prescribing. These may include inappropriate surgical antibiotic prophylaxis, unnecessary use of broad-spectrum antibiotics, delays in obtaining microbiological investigations, prolonged treatment courses, or inadequate reassessment of antimicrobial therapy.

A multidisciplinary team involving clinicians, surgeons, pharmacists, microbiologists, infectious disease specialists, and infection prevention professionals can help identify these problems and establish realistic priorities for improvement. By reviewing current prescribing practices, local resistance patterns, diagnostic procedures, and clinical outcomes, healthcare institutions can select interventions that are both scientifically appropriate and feasible within their organizational context.

Implementation should initially focus on a limited number of clearly defined measures that healthcare professionals can apply consistently in daily clinical practice. These may include establishing appropriate indications and durations for surgical antimicrobial prophylaxis, introducing regular reassessment of ongoing antibiotic treatment, improving the collection of microbiological specimens when clinically indicated, and providing structured feedback to prescribers.

Particular attention should be given to ensuring that antimicrobial treatment is regularly reviewed in light of the patient's clinical evolution and available diagnostic results. Such reassessment may support the discontinuation of unnecessary antibiotics, adjustment of treatment according to microbiological findings, or selection of a narrower-spectrum agent when appropriate. These decisions should always consider the severity of infection, the patient's clinical condition, and the need to maintain effective treatment.

Healthcare facilities with limited microbiological resources may face additional difficulties in implementing stewardship programmes. Nevertheless, meaningful improvements remain possible through standardized clinical assessment, clear prescribing protocols, appropriate referral arrangements, monitoring of antibiotic availability, and collaboration with laboratories capable of providing microbiological support. In these settings, limitations in diagnostic capacity should be explicitly recognized and documented, while progressive improvements in laboratory services should remain an important institutional objective.

Successful implementation also requires understanding the organizational factors that influence prescribing behaviour. Recommendations that appear straightforward in clinical guidelines may be difficult to apply when hospitals experience interruptions in antibiotic supplies, delayed laboratory results, insufficient staffing, limited access to specialist consultation, or uncertainty regarding professional responsibilities. For this reason, stewardship programmes should not rely exclusively on issuing new protocols. They should also identify practical barriers, involve frontline healthcare professionals in developing solutions, and provide the resources and support necessary to sustain improvements over time.

Continuous education, prescribing audits, and regular feedback can help strengthen adherence to recommended practices. However, monitoring should be used primarily to support professional development and quality improvement rather than simply identify deviations from guidelines. Healthcare teams should be encouraged to discuss difficult cases, evaluate the reasons behind prescribing decisions, and adapt interventions when local circumstances change.

At the national level, addressing antimicrobial resistance requires coordinated strategies involving human healthcare, veterinary medicine, agriculture, pharmaceutical regulation, and environmental protection. Effective national action plans should promote responsible antimicrobial use, strengthen infection prevention, improve access to reliable diagnostic services, ensure the quality

and availability of essential medicines, and support surveillance of antimicrobial resistance across relevant sectors.

Research and development remain essential for discovering new antimicrobial agents, improving diagnostic technologies, and identifying innovative strategies to prevent and treat resistant infections. However, scientific innovation alone cannot overcome the consequences of inadequate healthcare infrastructure, limited diagnostic capacity, or unequal access to effective treatment. Sustainable progress requires combining technological advances with investment in healthcare systems, professional education, effective governance, and international cooperation.

Finally, the implementation of antimicrobial stewardship should be understood as a continuous process of evaluation, adaptation, and improvement. Its success depends not only on the existence of clinical guidelines but also on the capacity of healthcare institutions to translate scientific evidence into safe, effective, and sustainable practices that respond to local needs while contributing to the global effort against antimicrobial resistance [32, 33].

Figure 5 illustrates the essential steps required to translate education and scientific knowledge into measurable, equitable, and sustainable improvements in patient safety. Education represents the starting point of this process, rather than its final objective. Although training is fundamental to developing professional knowledge, skills, and competencies, education alone cannot guarantee changes in clinical practice or improvements in patient outcomes.

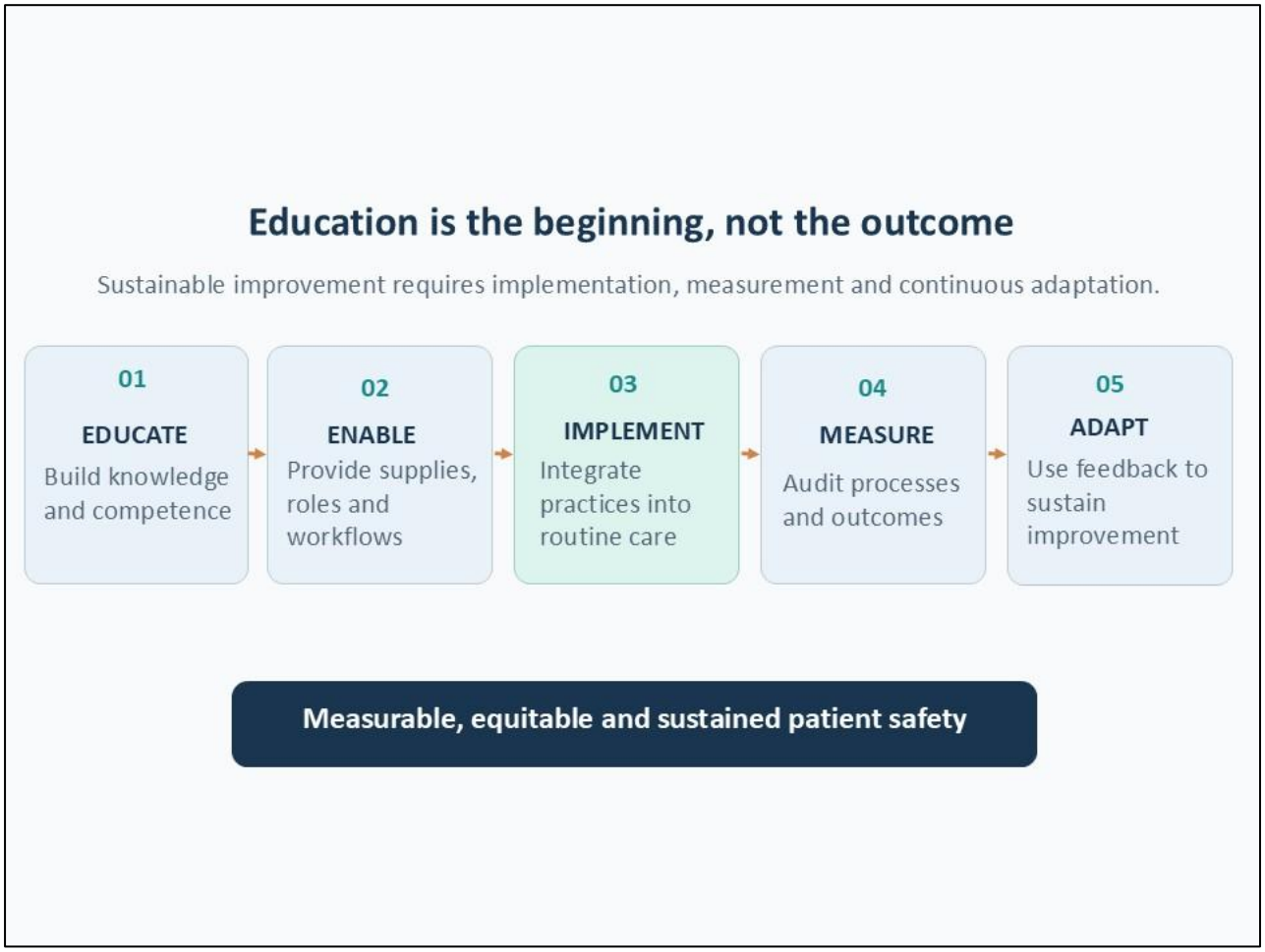


Figure 5. From education to implementation: translating knowledge into sustainable patient safety

Education linked to measurable prevention

Professional networks can play a fundamental role in strengthening infection prevention and control (IPC) by distributing scientific knowledge, facilitating training, comparing implementation experiences and supporting continuous feedback across institutions. However, education alone is not sufficient to produce lasting improvements in clinical practice. Knowledge represents an essential starting point, but its real value depends on the ability of healthcare systems to translate evidence into consistent, measurable and sustainable actions. Healthcare professionals may understand what should be done to prevent infections without necessarily having the organizational support, adequate resources, practical tools or institutional commitment required to apply that knowledge in their daily work.

This distinction between education and implementation is particularly important in infection prevention. Training programmes can improve awareness and professional competence, but

improvements in knowledge do not automatically translate into changes in clinical behaviour or patient outcomes. Effective prevention requires moving from knowing what works to ensuring that it is routinely performed. This transition depends on several interconnected factors, including leadership engagement, clearly assigned responsibilities, multidisciplinary collaboration, availability of essential supplies, monitoring of clinical practices and regular feedback. Educational initiatives should therefore be integrated into broader implementation strategies that address both individual behaviour and the organizational conditions influencing clinical decisions.

Implementation science provides a useful framework for understanding why evidence-based interventions may succeed in one healthcare setting but fail in another. Barriers to implementation may include limited staffing, inadequate infrastructure, competing clinical priorities, fragmented responsibilities, resistance to organizational change or the absence of reliable monitoring systems. Identifying these barriers before introducing an intervention is essential. Rather than assuming that providing information will automatically change practice, healthcare organizations should examine how care is actually delivered, involve frontline professionals in identifying practical obstacles and adapt interventions to local circumstances without compromising their essential evidence-based components.

A useful shared project might assess whether an educational and organizational intervention improves antimicrobial reassessment after 48–72 hours of treatment, using locally defined eligibility criteria and documented clinical exceptions. Training could explain the principles of antimicrobial stewardship, while implementation activities could introduce structured reassessment procedures, clarify professional responsibilities, integrate reminders into clinical workflows and establish periodic audits with feedback. The objective would not simply be to determine how many professionals attended a course, but whether antimicrobial prescriptions were appropriately reviewed, whether unnecessary treatment was discontinued or modified when clinically indicated, and whether these improvements were sustained over time.

A similar approach applies to the prevention of healthcare-associated infections. Following a workshop on device-associated infections, a multidisciplinary team could introduce a systematic daily review of invasive-device indications, establish clear criteria for device removal and monitor adherence to recommended practices. Education would explain the scientific rationale, while implementation would make the desired behaviour easier, more consistent and better integrated into routine patient care. Where appropriate, practical measures such as standardized checklists, bedside reminders, readily available supplies and regular team discussions could support this process. The effectiveness of the intervention should be assessed through feasible process indicators and, whenever possible, relevant clinical outcomes.

An important principle is that implementation should be adapted to available resources without becoming dependent on sophisticated technology or expensive monitoring systems. In healthcare settings with limited data infrastructure, short repeated observations, simple audit forms and regular multidisciplinary discussions may provide meaningful information. Small improvement cycles can help teams identify problems, test practical solutions and progressively strengthen adherence to preventive measures. The objective is not to collect the largest possible dataset or introduce the most complex intervention, but to establish a reliable feedback mechanism through which healthcare workers can recognize whether practices are improving and whether patients are receiving safer care.

Successful implementation also requires continuous evaluation and the willingness to modify interventions when expected improvements are not achieved. A training course may initially increase adherence to hand hygiene, antimicrobial stewardship or device management, but these gains can disappear if monitoring stops, supplies become unavailable or professional responsibilities remain unclear. Sustainable prevention therefore requires institutional ownership, repeated reinforcement, supportive supervision and integration of preventive practices into ordinary healthcare processes. Implementation should not be considered a temporary activity following education, but a continuous organizational responsibility.

International professional networks can make an additional contribution by supporting the exchange of implementation methodologies rather than simply transferring educational materials or standardized protocols. Healthcare institutions operating with limited resources often develop practical solutions that demonstrate how essential preventive measures can be maintained despite organizational and financial constraints. Such experiences represent valuable knowledge that can inform institutions in better-resourced settings as well. International collaboration should therefore encourage reciprocal learning, recognizing that innovation may consist not only of introducing new technologies, but also of simplifying processes, reducing unnecessary complexity and improving the use of existing resources.

Prevention is also a fundamental measure of health equity. Patients receiving care in underserved regions should not face avoidable infections simply because basic consumables, safe water, adequate sanitation, trained personnel or essential preventive systems are unavailable. At the same time, educational programmes cannot compensate for structural inequalities that prevent healthcare professionals from applying recommended practices. It would be unrealistic and ethically questionable to demand adherence to infection-prevention standards without ensuring the minimum conditions necessary to implement them. International cooperation should therefore connect education with capacity building, access to essential resources, organizational development and long-term institutional support.

Ultimately, the success of education in infection prevention should not be measured primarily by the number of courses delivered, professionals trained or educational materials distributed. These indicators describe the reach of an initiative, but not necessarily its impact. The true measure of success is whether knowledge produces sustained improvements in clinical practice, reduces preventable harm and strengthens the capacity of healthcare systems to protect patients. Education creates awareness and competence; implementation transforms that competence into action; continuous evaluation makes improvement visible and sustainable. Only by integrating these three dimensions can professional collaboration move beyond the transmission of knowledge and contribute to measurable, equitable and lasting improvements in patient safety.

Key messages

- Infection prevention, diagnostics and antimicrobial stewardship should function as a coordinated patient-safety strategy.
- Translate evidence into feasible routines supported by staffing, supplies, leadership and feedback.
- Interpret antimicrobial-resistance burden carefully, distinguishing associated deaths from attributable deaths.
- Track practical process measures alongside clinical outcomes and adapt interventions to local epidemiology.

7
One Health, climate and sustainable care

Health exists within ecological systems

The One Health approach recognizes that human health is closely connected to the health of animals and the environment. These three dimensions continuously influence one another, and changes affecting one can have important consequences for the others. Addressing global health challenges therefore requires collaboration among professionals from different disciplines, including human medicine, veterinary medicine, environmental sciences, agriculture, and public health.

The practical application of One Health depends on the ability of these sectors to identify common problems, share relevant information, and develop coordinated responses. Antimicrobial resistance provides a clear example of this interdependence. Understanding the emergence and spread of resistant microorganisms may require information about antibiotic use in hospitals and communities, antimicrobial consumption in veterinary medicine, agricultural practices, wastewater contamination, food production, and environmental exposure.

However, information collected from different sectors cannot always be directly compared. Surveillance systems may use different methods of sampling, laboratory testing, data collection, and reporting. These differences must be recognized when interpreting findings and developing public health interventions. Effective collaboration therefore requires shared objectives, transparent methods, and clearly defined responsibilities among the institutions involved.

Human health is also influenced by broader ecological changes. Deforestation, modifications in land use, intensive animal production, biodiversity loss, and increasing human mobility may alter the interactions between people, animals, and infectious agents. These changes can influence the emergence and geographical distribution of infectious diseases, particularly when human activities increase contact with wildlife or modify existing ecological relationships.

Similarly, antimicrobial use in human and veterinary medicine, together with the release of pharmaceutical residues and resistant microorganisms into the environment, may contribute to the development and circulation of antimicrobial resistance across different ecosystems. Understanding these connections is essential for designing prevention strategies that address the underlying factors contributing to health threats rather than focusing exclusively on their clinical consequences.

The One Health approach provides a framework for addressing these interconnected challenges through cooperation between healthcare institutions, veterinary services, environmental agencies, research organizations, and local communities. Its effectiveness depends on transforming interdisciplinary collaboration into practical activities, including coordinated surveillance, responsible antimicrobial use, environmental monitoring, and shared prevention programmes.

Joint surveillance is particularly valuable because information relevant to the same health threat is often collected and managed by separate institutions. Bringing together human, animal, and environmental data may improve the identification of emerging risks and support earlier public health responses. Nevertheless, data integration must respect privacy requirements, acknowledge methodological limitations, and ensure that the information collected can guide realistic interventions.

Ultimately, One Health highlights the importance of approaching global health through an integrated perspective. Protecting human health requires attention not only to healthcare services and medical treatments, but also to the ecological, agricultural, and environmental conditions that influence disease emergence and transmission. Strengthening cooperation across these sectors is therefore an important component of more effective and sustainable global health strategies [24].

Figure 6 illustrates the One Health approach, emphasizing the interdependence of human health, animal health, and the environment. These three interconnected domains cannot be effectively addressed in isolation, as infectious diseases, antimicrobial resistance, environmental degradation, and emerging health threats frequently cross biological, ecological, and geographical boundaries. At the centre of this framework is integrated surveillance and shared scientific evidence, supported by comparable data, transparent methodologies, and clearly defined responsibilities among different sectors. This integration enables the early identification of emerging risks, the development of coordinated prevention strategies, the responsible use of antimicrobials in human and veterinary medicine, and the protection of environmental ecosystems. Importantly, the figure highlights that collecting and sharing scientific information is not sufficient unless it is translated into coordinated, measurable, and sustainable interventions. The One Health approach therefore requires continuous collaboration among healthcare professionals, veterinarians, environmental scientists, public health authorities, and policymakers, transforming knowledge across disciplines into practical actions that protect human, animal, and planetary health.

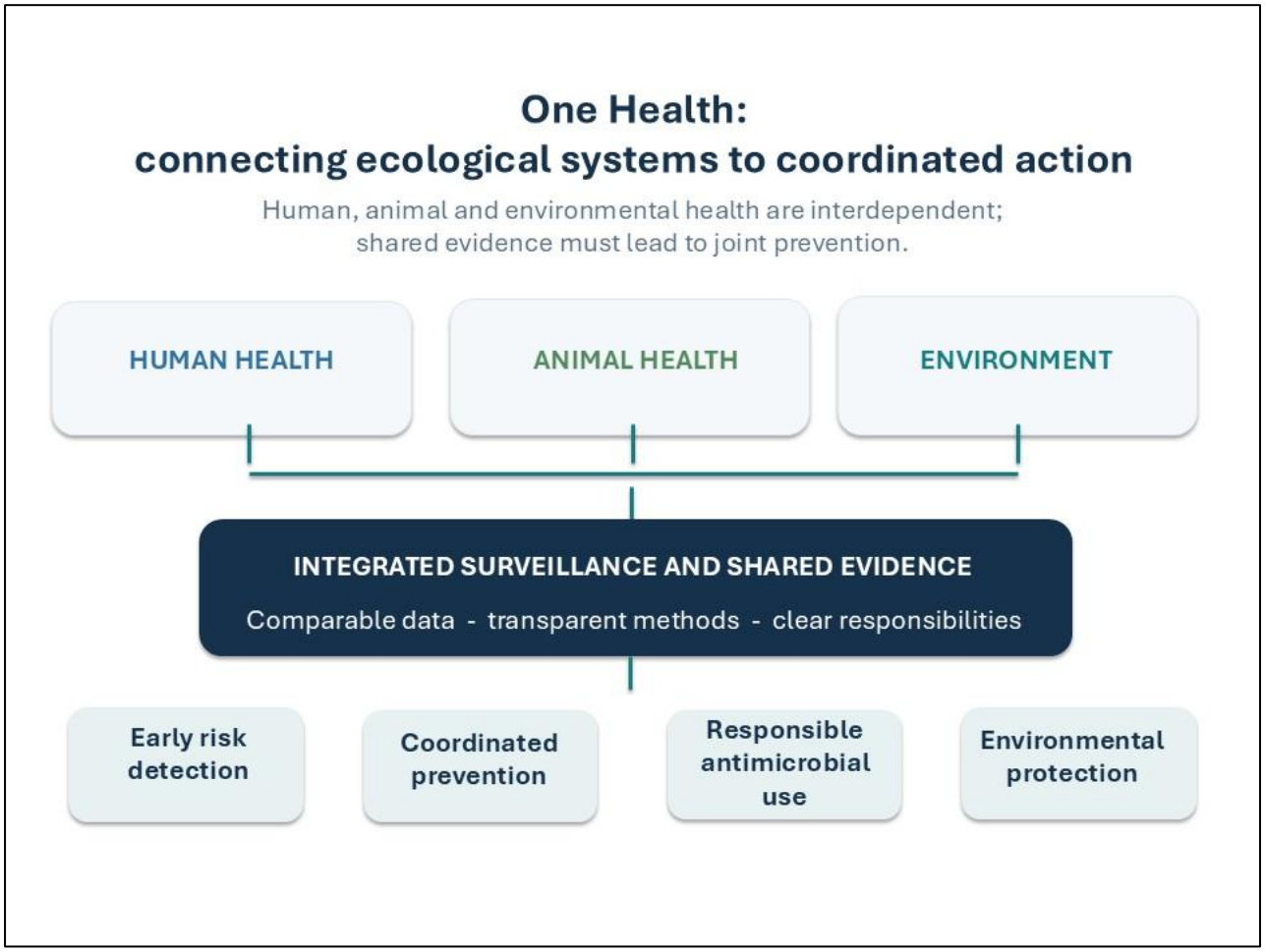


Figure 6. One Health: connecting ecological systems to coordinated action.

Climate adaptation as healthcare planning

Climate change represents a growing challenge for healthcare systems because its effects extend beyond the environment and directly influence human health, healthcare demand, and the availability of essential services. Rising temperatures, extreme weather events, changes in rainfall patterns, droughts, floods, and other climate-related hazards can increase the burden of disease while placing additional pressure on healthcare infrastructure and personnel.

The health consequences of climate change are diverse. Heat waves can increase the incidence of heat-related illness and aggravate existing cardiovascular, respiratory, and renal conditions. Changes in temperature and precipitation may influence the distribution of vectors responsible for transmitting infectious diseases. Extreme weather events can cause traumatic injuries, disrupt access to safe drinking water, affect food security, and contribute to psychological distress and other mental health consequences.

These risks are not equally distributed across populations. Older adults, children, individuals with chronic illnesses, outdoor workers, and people living in poorly insulated or overcrowded housing may be particularly vulnerable. Socioeconomic conditions, geographical location, occupational exposure, and access to healthcare services can strongly influence the ability of individuals and communities to protect themselves from climate-related hazards.

For these reasons, climate adaptation should be considered an essential component of healthcare planning rather than a responsibility limited to environmental institutions. Healthcare systems must be prepared not only to treat illnesses associated with climate change, but also to maintain the continuity and safety of essential services during extreme environmental conditions.

Heat waves provide an important example. During periods of extreme temperatures, hospitals may experience increased demand for emergency services while simultaneously facing difficulties related to staff working conditions, indoor temperature control, electricity consumption, and the storage of temperature-sensitive medicines. Inadequate cooling or interruptions in electricity supplies can compromise both patient safety and healthcare operations.

Flooding and severe storms may produce different but equally serious consequences. Healthcare facilities can become inaccessible because of damaged roads or interrupted transportation networks. Water contamination, power failures, communication disruptions, and damage to medical equipment may interfere with emergency care, diagnostic services, and the distribution of essential medicines.

Strengthening climate resilience therefore requires healthcare institutions to identify their most important vulnerabilities and develop practical plans to maintain essential functions during emergencies. These plans may include reliable backup electricity and water supplies, emergency communication systems, alternative transportation arrangements, protection of medical stocks, and procedures for relocating patients when necessary.

Healthcare professionals should also receive appropriate training to recognize and manage climate-related health conditions. Emergency departments, primary healthcare services, public health authorities, and community organizations can contribute to early identification of vulnerable individuals and the implementation of preventive measures during periods of increased environmental risk.

Preparedness should be integrated into routine healthcare management and periodically evaluated through practical exercises involving the professionals responsible for implementing emergency procedures. Particular attention should be given to situations in which multiple disruptions occur simultaneously, such as flooding combined with electricity failure, transport interruption, or shortages of essential supplies.

Climate adaptation also requires effective epidemiological surveillance. Monitoring heat-related illness, climate-sensitive infectious diseases, and other relevant health indicators can help institutions anticipate changing healthcare needs and improve the allocation of resources.

Finally, healthcare systems must develop the capacity to respond to immediate climate-related emergencies while progressively adapting their infrastructure, workforce organization, and service delivery to changing environmental conditions. Incorporating climate resilience into healthcare planning is essential for protecting vulnerable populations, maintaining continuity of care, and strengthening the long-term sustainability of health systems [4, 34].

Reducing healthcare's own environmental burden

Healthcare systems play a fundamental role in protecting human health, but their activities also consume substantial amounts of energy, water, materials, and other natural resources. Hospitals and healthcare facilities generate environmental impacts through building operations, transportation, pharmaceutical production and consumption, medical equipment, procurement processes, and waste management. Improving the environmental sustainability of healthcare is therefore an important component of broader efforts to protect population health and reduce the long-term consequences of environmental degradation.

However, sustainability in healthcare must always be pursued alongside clinical effectiveness, patient safety, infection prevention, and equitable access to essential services. Environmental objectives should support the quality of healthcare rather than compromise it. Decisions intended to reduce resource consumption must therefore be based on a careful assessment of their potential benefits, limitations, and consequences for patients and healthcare professionals.

A central consideration is the environmental impact of medical products and healthcare activities throughout their entire life cycle. For example, comparing reusable and disposable medical devices requires more than considering the quantity of waste generated after use. A comprehensive assessment should also examine manufacturing processes, transportation, energy and water consumption, cleaning and sterilization requirements, waste treatment, and the reliability of supply chains.

The environmental advantages of a particular product or procedure may differ between healthcare settings. Reusable equipment may offer benefits where efficient sterilization facilities and reliable infrastructure are available, while its environmental or operational performance may be less favorable under different conditions. For this reason, sustainability strategies should be adapted to local resources and supported by reliable evidence rather than assumptions about which products appear more environmentally friendly.

Healthcare professionals should actively participate in decisions concerning sustainable procurement and organizational changes. Surgeons, nurses, pharmacists, infection prevention specialists, hospital managers, and technical personnel can contribute valuable information about the clinical requirements, safety considerations, and practical implications of proposed interventions.

Environmental sustainability can also be promoted by improving the efficiency of healthcare delivery. Avoiding unnecessary investigations, reducing low-value interventions, preventing healthcare-associated infections, and improving the coordination of patient care may contribute to more responsible resource use while supporting better clinical outcomes.

Prevention is particularly important because avoiding disease and complications can reduce the need for additional treatments, hospitalization, and medical resources. Effective vaccination programmes, infection prevention measures, early diagnosis, and appropriate management of chronic conditions can therefore contribute to both population health and the efficient use of healthcare resources.

Nevertheless, reducing environmental impact should never become a justification for limiting necessary treatment or accepting lower standards of care. Sustainability must not be confused with reducing expenditure at the expense of patients. Its objective is to use available resources responsibly while preserving access to safe, effective, and high-quality healthcare.

A sustainable healthcare system should also protect its workforce, maintain essential infrastructure, and remain capable of responding to future health emergencies. This requires long-term planning, responsible investment, and the integration of environmental considerations into clinical governance and institutional decision-making.

Ultimately, reducing the environmental burden of healthcare is part of a broader commitment to protecting both present and future generations. By combining scientific evidence, clinical safety, efficient resource management, and environmental responsibility, healthcare institutions can contribute to a more sustainable model of care that supports human health without creating avoidable harm to the ecosystems on which it depends [35].

Learning across ecological boundaries

Human health cannot be fully understood in isolation from the health of animals, ecosystems, and the environments in which communities live. Infectious diseases, antimicrobial resistance, climate change, environmental degradation, food production, and access to safe water are interconnected challenges that extend beyond traditional disciplinary and institutional boundaries. Their complexity requires educational approaches capable of bringing together different forms of scientific expertise and practical experience.

The One Health approach provides an important framework for understanding these relationships. It recognizes that the health of humans, domestic and wild animals, plants, and the wider environment is closely linked and interdependent. Rather than considering these domains as separate areas of responsibility, One Health encourages coordinated action among healthcare professionals, veterinarians, environmental scientists, agricultural specialists, public health authorities, and communities.

This perspective has significant implications for global health education. Traditional professional training is frequently organized around specialized disciplines, each with its own scientific methods, institutional structures, and professional responsibilities. Specialization is essential for developing advanced competencies, but it can also limit opportunities to recognize problems that extend across different sectors. Educational programmes that encourage interdisciplinary learning can help overcome these limitations by showing how decisions made in one domain may influence health outcomes in another.

Cross-disciplinary cooperation can bring together infectious disease specialists, veterinarians, microbiologists, pharmacists, epidemiologists, climate researchers, environmental scientists, agricultural professionals, and community representatives around shared health challenges. Each contributes a different perspective on the origins, transmission, consequences, and prevention of health threats. Combining these perspectives can improve the understanding of complex problems and support more comprehensive approaches to prevention and response.

The educational value of this cooperation lies not simply in presenting information from multiple disciplines, but in helping participants understand how different systems interact. A clinical problem may have environmental determinants, an agricultural practice may influence antimicrobial resistance, and an environmental intervention may produce both health benefits and unintended consequences. Learning across ecological boundaries encourages professionals to examine these connections and consider how decisions can affect people, animals, and ecosystems simultaneously.

Practical examples are particularly useful for illustrating these relationships. Water management, for instance, influences several dimensions of health and social well-being. Access to safe drinking water and adequate sanitation is fundamental to preventing many infectious diseases. At the same time, water availability affects agricultural production, food security, environmental sustainability, and the resilience of urban and rural communities.

Decisions concerning water storage, irrigation, wastewater treatment, and the management of natural water systems may influence exposure to pathogens, environmental contamination, and the distribution of disease vectors. Poorly managed water storage can create conditions favourable to mosquito breeding, while inadequate wastewater treatment may contribute to the

dissemination of microbial contaminants and antimicrobial resistance determinants into the environment.

Water scarcity introduces additional challenges. When communities experience prolonged drought, unreliable water supplies, or damage to essential infrastructure, maintaining hygiene and sanitation becomes more difficult. Healthcare facilities may struggle to sustain infection prevention practices, agricultural production may be affected, and vulnerable populations may face increasing risks related to inadequate water quality and availability.

These consequences demonstrate why water management cannot be considered exclusively an engineering, agricultural, or environmental issue. It is also a public health concern requiring coordinated planning across sectors. Educational activities based on such examples can help participants understand how preventive measures, infrastructure investments, environmental protection, and healthcare delivery contribute to shared health objectives.

Climate change provides another important example of interconnected health risks. Rising temperatures, changing precipitation patterns, extreme weather events, and ecological disruption can influence the distribution of disease vectors, the occurrence of heat-related illness, food and water security, and the capacity of healthcare systems to maintain essential services.

However, climate-related health effects are not uniform. Their consequences depend on geographical location, population vulnerability, infrastructure, economic resources, and the ability of institutions to anticipate and respond to environmental changes. Educational programmes should therefore avoid presenting climate change as a single, homogeneous health threat. Instead, they should help learners understand the different pathways through which environmental changes influence health and the context-specific strategies required to reduce associated risks.

For example, increasing temperatures may alter the geographical suitability of certain environments for disease vectors, but the occurrence of vector-borne disease also depends on ecological conditions, human exposure, vector control, surveillance, and healthcare capacity. Similarly, flooding can damage sanitation systems, contaminate water supplies, interrupt healthcare services, and increase exposure to environmental hazards, although the precise consequences vary between settings.

Understanding these relationships requires cooperation between climate scientists, epidemiologists, environmental specialists, healthcare professionals, and local authorities. Climate researchers can provide information about environmental trends and potential hazards, while public health practitioners contribute knowledge about population vulnerability, disease surveillance, and preventive interventions. Healthcare professionals can identify the consequences for clinical services, and community representatives can help explain how environmental changes affect everyday living conditions.

The integration of these perspectives supports the development of educational activities that connect scientific evidence with practical preparedness. Rather than focusing exclusively on environmental predictions or disease statistics, programmes can explore how institutions might adapt surveillance systems, protect essential infrastructure, strengthen communication, and support vulnerable communities.

Antimicrobial resistance represents another area in which learning across ecological boundaries is essential. The emergence and dissemination of resistant microorganisms involve complex interactions among human healthcare, veterinary medicine, agriculture, food systems, and the environment. Antimicrobial use in different sectors can contribute to selection pressures, while microorganisms and resistance determinants may circulate through multiple ecological pathways.

A comprehensive educational approach to antimicrobial resistance should therefore extend beyond prescribing practices in hospitals and community healthcare. It should also consider antimicrobial use in animal health, infection prevention in agricultural settings, environmental contamination, wastewater management, food production, and the broader conditions that influence the emergence and spread of resistance.

This does not diminish the importance of antimicrobial stewardship in human medicine. Appropriate prescribing, timely diagnosis, infection prevention and control, and effective surveillance remain essential. However, these interventions are more meaningful when understood as components of a wider system in which actions undertaken in different sectors may influence one another.

Interdisciplinary learning can help professionals recognize both shared responsibilities and sector-specific priorities. Physicians and pharmacists may focus on optimizing antimicrobial treatment, veterinarians may address responsible antimicrobial use and animal disease prevention, microbiologists may investigate resistance mechanisms, and environmental scientists may examine pathways of contamination and environmental dissemination.

Bringing these perspectives together can improve communication and promote a more integrated understanding of antimicrobial resistance. It can also encourage educational programmes to move beyond isolated technical recommendations toward coordinated approaches that consider the relationships between antimicrobial use, infection prevention, surveillance, and environmental protection.

Food systems provide another opportunity for interdisciplinary education. Agricultural production, animal health, food processing, distribution, and consumption all influence population health. Foodborne infections, nutritional insecurity, environmental pressures, and the sustainability of agricultural practices illustrate how health outcomes depend on decisions extending well beyond healthcare institutions.

A disturbance affecting agricultural production may influence food availability and nutritional status, while contamination at different stages of the food supply chain can create risks that cross geographical boundaries. Changes in land use, agricultural intensification, and interactions between humans, livestock, and wildlife may also influence opportunities for pathogen exposure and transmission.

Educational programmes can use these examples to demonstrate how public health protection requires cooperation among agricultural authorities, veterinary services, environmental institutions, food safety professionals, and healthcare systems. Understanding the entire pathway from environmental conditions and production practices to human exposure and clinical consequences can support more effective prevention strategies.

The relationship between ecosystem change and emerging infectious diseases further illustrates the importance of integrated learning. Human activities that alter habitats, expand settlements, or modify interactions among people, domestic animals, and wildlife may change opportunities for pathogen transmission. These processes are influenced by multiple ecological and social factors and cannot be reduced to a single cause.

Educational initiatives should therefore encourage careful interpretation of scientific evidence and avoid simplistic explanations that attribute complex disease emergence to one environmental or human activity. A multidisciplinary perspective helps learners recognize uncertainty, distinguish established mechanisms from emerging hypotheses, and evaluate the relevance of different risk factors.

Community participation is particularly important in this process. Environmental and health interventions can affect livelihoods, agricultural practices, access to natural resources, and established social relationships. Communities may possess detailed knowledge of local ecological conditions, seasonal changes, exposure patterns, and practical constraints that is not fully captured by formal scientific data.

Including community representatives in educational discussions can improve understanding of these circumstances and help ensure that proposed interventions are culturally appropriate, feasible, and responsive to local needs. Community knowledge should not replace scientific investigation, but it can complement formal evidence and support more informed decisions.

Learning across ecological boundaries also requires attention to the different priorities and responsibilities of participating sectors. Public health institutions may focus on disease prevention, agricultural authorities on food production, environmental agencies on ecosystem protection, and healthcare organizations on the delivery of clinical services. These objectives are often compatible, but tensions can arise when interventions generate different benefits, costs, or operational demands.

For example, measures intended to reduce antimicrobial use in animal production must consider animal health, veterinary access, agricultural practices, and economic consequences. Similarly, environmental policies affecting water use or land management may have implications for public health, food security, and local livelihoods.

Interdisciplinary education can provide opportunities to examine these trade-offs openly. By considering the perspectives of different stakeholders, learners can develop a more realistic understanding of the decisions required to balance competing priorities while protecting health and environmental sustainability.

This form of learning is particularly valuable when organized around practical cases rather than isolated disciplinary presentations. Case-based discussions can begin with a specific problem, such as water contamination, an emerging zoonotic infection, or the detection of antimicrobial resistance in different sectors, and invite participants to examine its clinical, environmental, organizational, and social dimensions.

Participants can identify relevant stakeholders, discuss available evidence, consider potential interventions, and evaluate how different decisions might affect human health, animal health, and ecosystems. Such activities encourage systems thinking and help professionals recognize the limitations of approaches developed within a single discipline.

The objective is not to transform every healthcare professional into an expert in environmental science, veterinary medicine, or agriculture. Rather, it is to develop sufficient understanding of interconnected risks to recognize when collaboration is necessary, communicate effectively with other sectors, and contribute appropriately to coordinated responses.

This distinction is important for the design of educational programmes. Interdisciplinary learning should complement professional specialization rather than replace it. Strong disciplinary expertise remains essential, but professionals should also understand how their decisions interact with wider health and environmental systems.

Educational institutions can support this objective by introducing shared learning modules, interdisciplinary seminars, joint case discussions, and collaborative projects involving students and professionals from different backgrounds. These activities may be particularly valuable when they address problems that participating institutions have identified as relevant to their local circumstances.

For students and early-career professionals, exposure to interdisciplinary perspectives can encourage a broader understanding of professional responsibility. It can also strengthen communication skills, collaborative problem-solving, and the ability to evaluate evidence from different scientific fields.

These competencies are increasingly important because many contemporary health challenges cannot be addressed effectively through isolated professional action. Climate-related emergencies, antimicrobial resistance, zoonotic diseases, environmental contamination, and disruptions to food and water systems require coordination among institutions with different expertise and responsibilities.

International educational networks can facilitate this process by connecting professionals who might otherwise have limited opportunities for interaction. Shared online discussions, collaborative educational resources, and multidisciplinary workshops can support the exchange of experiences across countries and sectors.

However, the effectiveness of these activities depends on more than the presence of multiple disciplines. Successful collaboration requires common objectives, clear communication, mutual respect, and recognition that different fields may use distinct terminology, methods, and standards of evidence.

Educational programmes should therefore help participants develop a shared language for discussing complex health problems without oversimplifying the scientific contributions of individual disciplines. This can improve the quality of collaboration and reduce misunderstandings that may arise when professionals interpret the same issue through different conceptual frameworks.

The translation of interdisciplinary learning into practical action also requires institutional support. Collaboration among healthcare, veterinary, agricultural, environmental, and public health organizations may be limited by fragmented responsibilities, incompatible information systems, insufficient resources, or unclear governance arrangements.

Education can improve awareness of these barriers, but overcoming them may require formal cooperation agreements, shared surveillance activities, coordinated planning, and mechanisms for exchanging relevant information. International networks can contribute by disseminating examples of effective coordination and helping institutions identify approaches suitable for their own circumstances.

Evaluation should remain an integral component of these initiatives. Interdisciplinary education may be assessed through improvements in knowledge, communication, collaborative competencies, and the ability to recognize connections across sectors. Where programmes are linked to practical interventions, evaluation can also examine whether cooperation improves surveillance, preparedness, implementation, or other relevant processes.

The choice of indicators should reflect the objectives of the activity and the resources available. Not every educational initiative will produce immediately measurable changes in population health, but it should contribute to clearer understanding, more effective professional relationships, or stronger capacity for coordinated action.

An important long-term objective is to develop institutions capable of anticipating interconnected threats rather than responding only after their consequences become visible. This requires professionals who can recognize emerging risks, understand their possible implications across sectors, and participate in preventive planning.

Learning across ecological boundaries is therefore closely connected to resilience. Healthcare systems cannot remain resilient if they ignore the environmental and social conditions upon which their functioning depends. Reliable water supplies, food security, environmental protection, sustainable resource management, and effective surveillance contribute to the ability of institutions and communities to withstand disruptions and maintain essential services.

At the same time, resilience should not be understood exclusively as the responsibility of healthcare institutions. It depends on coordinated action across multiple sectors and on policies that recognize the connections between human well-being and ecological stability.

A borderless philosophy of global health must consequently extend beyond the exchange of knowledge between countries or healthcare professions. It must also encourage cooperation across the boundaries separating human health, animal health, environmental science, agriculture, and community development.

The essential lesson of interdisciplinary global health education is that complex health challenges rarely follow the boundaries through which institutions organize their responsibilities.

Scientific disciplines provide indispensable expertise, but their combined contribution becomes particularly valuable when they are connected through shared objectives, reciprocal learning, and coordinated action.

By bringing together different forms of knowledge and experience, educational networks can help professionals understand how environmental decisions influence health, how healthcare practices interact with wider ecological systems, and how preventive strategies can generate benefits across sectors.

Ultimately, learning across ecological boundaries strengthens the capacity to recognize interdependence, anticipate shared risks, and develop responses that are scientifically informed, context-sensitive, and sustainable.

Protecting human health requires understanding the systems that sustain it. A truly borderless approach to global health therefore connects people, animals, ecosystems, and institutions through education, scientific cooperation, and collective responsibility for a healthier and more resilient future.

Key messages

- Apply a One Health perspective to the shared determinants of human, animal and environmental health.
- Prepare healthcare facilities for climate-related disruption of water, energy, supplies, workforce and services.
- Reduce environmental impact using measurable changes that preserve infection prevention and patient safety.
- Make cross-sector collaboration practical through shared surveillance, planning and local implementation.

8

Food security, nutrition and the double burden of malnutrition

Food security as a foundation of health

Food security exists when people have reliable physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and supports a healthy life. This definition goes beyond the availability of calories. Food must be affordable, nutritionally adequate, culturally acceptable and accessible throughout the year. The four interconnected dimensions of food security—availability, access, utilization and stability—help explain why an adequate national food supply can coexist with hunger in particular communities. Families may live near food markets yet be unable to purchase healthy products; others may grow sufficient crops but lack safe water, storage facilities or reliable transport. Food security is therefore inseparable from poverty reduction, environmental conditions, education and equitable development [36].

The consequences of food insecurity extend well beyond hunger. Irregular or inadequate diets increase vulnerability to infection, impair recovery from illness, complicate the management of chronic diseases and undermine physical and cognitive development. Food insecurity can also generate anxiety, difficult choices between medicines and meals, and long-term financial pressure on households. Women, infants, children, older adults, people with disabilities and displaced populations may face particular risks. Identifying those risks requires looking within countries and communities rather than relying solely on national food production or average income.

The double burden of malnutrition

Malnutrition includes both insufficient and excessive or imbalanced nutrition. Undernutrition encompasses wasting, stunting, underweight and deficiencies of essential vitamins and minerals. At the same time, overweight, obesity and diet-related noncommunicable diseases—including type 2 diabetes and cardiovascular disease—are major health challenges. The double burden of malnutrition describes the coexistence of undernutrition and overweight, obesity or diet-related noncommunicable diseases within the same country, community, household or even individual across the life course. These conditions are not contradictory. They can arise from food systems that provide inexpensive energy while making diverse, nutrient-rich diets difficult to obtain.

For example, a household may experience childhood micronutrient deficiencies while adults consume energy-dense but nutritionally poor foods and develop obesity. A person who experienced inadequate nutrition early in life may later encounter an environment that encourages excessive

consumption and physical inactivity. Consequently, nutrition policy cannot be divided into separate, competing agendas for hunger and obesity. It should address dietary quality, social vulnerability and the wider conditions shaping food choices. Well-designed interventions can have double-duty benefits by reducing undernutrition risks without inadvertently increasing obesity or other diet-related disease risks.

Nutrition throughout the life course

Maternal nutrition, adequate prenatal care, breastfeeding support and appropriate complementary feeding are particularly important during pregnancy and early childhood. Nutritional deprivation during these periods can have consequences that persist throughout life. Later, school meals and healthy educational environments can improve children's access to nutritious food and encourage sustainable dietary habits. In adulthood and older age, nutritional needs change with health status, living conditions and functional ability. A life-course perspective therefore connects family support, education, clinical services, social protection and healthy ageing rather than treating nutrition as an isolated intervention.

Nutrition also influences the effectiveness of healthcare. Inadequate intake may contribute to poor wound healing, reduced resilience during severe illness and more difficult rehabilitation. Overnutrition and poor dietary quality can increase the long-term burden of metabolic disease. Primary healthcare teams should therefore be able to recognize nutritional risks, offer appropriate advice and refer patients for specialized assessment when needed. However, clinical counselling alone is insufficient when households cannot afford the recommended foods or lack the means to prepare them safely.

Food environments, affordability and commercial influences

Dietary choices are strongly influenced by the environments in which people live and work. Prices, household income, local food availability, transport, refrigeration, marketing and time available for food preparation all matter. In many settings, inexpensive, highly processed products are more readily available than fresh or minimally processed alternatives. Healthy eating cannot be framed entirely as an issue of individual motivation when healthier options are structurally inaccessible. The 2026 State of Food Security and Nutrition in the World report emphasizes the persistent economic barriers to healthy diets and the need to address costs across food systems. [36] Responses may combine social assistance, school food programmes, appropriate food standards, transparent product information, support for local producers and policies that improve access to affordable nutritious foods. Regulation of marketing directed towards children and responsible procurement in schools and healthcare institutions can help create healthier food environments.

Such policies should be proportionate, evidence-informed and assessed for unintended consequences, including price increases that could disadvantage low-income households.

Climate, conflict and resilient food systems

Food systems depend on water, healthy soils, biodiversity, energy, transport and stable institutions. Droughts, floods, extreme temperatures, crop diseases, and disrupted distribution networks can reduce harvests, raise prices, and weaken food supply stability. Armed conflict and displacement can intensify these effects by destroying livelihoods, damaging infrastructure, and disrupting humanitarian assistance. Climate change therefore connects food security with environmental protection, disaster preparedness and health-system resilience.

Building resilience requires diversified production and supply chains, sustainable water and land management, protection of rural livelihoods, early-warning systems and effective coordination between agriculture, health, education and social protection. Emergency food assistance remains indispensable during acute crises, but long-term security also depends on restoring local capacity and reducing dependence on fragile external supply arrangements. International partners should support locally defined priorities and draw on the practical expertise of communities that manage food and nutrition under difficult conditions.

From nutrition education to measurable action

Education can improve nutritional knowledge, but information does not automatically change access or outcomes. Effective programmes must address the practical obstacles that prevent families from obtaining and using appropriate foods. A locally designed project might combine nutritional counselling with affordable food access, safe water, maternal care and community participation. Its planning should define the target population, responsibilities, resources, implementation barriers and a process for adapting the intervention when results are disappointing.

Evaluation should distinguish programme activity from meaningful health benefits. Relevant indicators can include household food insecurity, dietary diversity, the affordability of healthy diets, child growth, anaemia and the prevalence of overweight or obesity, selected according to local epidemiology and measurement capacity. Disaggregated results can reveal whether progress reaches vulnerable communities. The objective is not simply to deliver more food or provide more dietary advice, but to improve the sustained ability of people to obtain nutritious diets while protecting health, dignity and the environment.

Ultimately, food security and nutrition are shared responsibilities that extend far beyond the healthcare sector. Sustainable progress depends on policies that connect agriculture, social protection, education, public health, environmental stewardship and fair economic opportunities.

Addressing the double burden of malnutrition requires a common commitment to preventing both nutritional deprivation and diet-related disease, with interventions adapted to local realities and evaluated through measurable improvements in well-being.

Key messages

- Food security requires affordable, safe and nutritious diets, not simply sufficient national food supplies.
- Undernutrition and obesity can coexist; policies should address both through equitable, life-course approaches.
- Healthy food environments depend on social protection, accessible choices and resilient food systems as well as individual education.
- Measure dietary quality, financial access and health outcomes, paying attention to groups left behind.

9
Conflict, displacement and humanitarian health

The indirect health effects of violence

Armed conflicts represent one of the most serious challenges to global health because their consequences extend far beyond the injuries and deaths directly caused by violence. Wars and prolonged humanitarian crises can disrupt entire healthcare systems, damage essential infrastructure, interrupt public health programmes, and undermine the social and economic conditions necessary for maintaining population health. As a result, the indirect consequences of conflict may persist for many years, affecting individuals and communities long after active hostilities have ended.

The destruction or deterioration of healthcare facilities is among the most immediate consequences of armed conflict. Hospitals, primary healthcare centres, laboratories, and emergency medical services may become inaccessible, damaged, or unable to function because of shortages of electricity, water, medicines, and essential equipment. Even when healthcare facilities remain physically intact, their ability to provide appropriate care may be severely compromised by interruptions in supply chains, increasing patient demand, and the loss of qualified healthcare personnel.

Healthcare workers are particularly affected by these circumstances. Some may be injured, displaced, or forced to leave their communities, while those who remain often face overwhelming workloads, unsafe working conditions, and limited access to essential supplies. The reduction in available personnel can affect all areas of healthcare, including emergency medicine, surgery, maternal and neonatal care, infection prevention, and the management of chronic diseases. Over time, the loss of experienced professionals may also weaken medical education, professional training, and the capacity of healthcare institutions to recover.

The impact of conflict on public health extends beyond the interruption of hospital services. Vaccination programmes may be suspended, routine screening activities disrupted, and access to essential medicines reduced. Damage to water and sanitation infrastructure can increase the risk of infectious diseases, particularly in overcrowded communities and temporary settlements where access to safe drinking water and adequate hygiene facilities may be limited.

Malnutrition and food insecurity represent additional consequences of prolonged conflict. Disruptions in agricultural production, transportation, markets, and food distribution can reduce access to adequate nutrition, particularly among children, pregnant women, older adults, and individuals with pre-existing medical conditions. Poor nutritional status can increase vulnerability to infectious diseases, delay recovery from illness, and contribute to longer-term health complications.

Conflicts can also substantially affect the management of noncommunicable diseases. Patients with diabetes, cardiovascular disease, chronic respiratory conditions, cancer, or other long-term illnesses may experience interruptions in treatment because medicines are unavailable, healthcare facilities are inaccessible, or medical records have been lost. In these circumstances, conditions that would normally be manageable may progress to severe complications requiring emergency treatment or hospitalization.

Maternal and child health services are especially vulnerable to healthcare disruptions. Pregnant women may face difficulties accessing antenatal consultations, skilled birth attendance, emergency obstetric care, and appropriate postnatal follow-up. Interruptions in reproductive healthcare and childhood vaccination programmes can have consequences that extend beyond the immediate emergency, potentially affecting maternal and child health for years.

Surgical and emergency care may also deteriorate significantly during conflict. Although traumatic injuries often receive considerable attention, many patients continue to require treatment for non-traumatic surgical emergencies, including acute abdominal conditions, obstetric complications, and other potentially life-threatening diseases. Shortages of anaesthesia personnel, blood products, antibiotics, sterile equipment, and postoperative care capacity can limit the safety and availability of these essential services.

Forced displacement adds further complexity to these challenges. Individuals and families may be required to leave their homes and move within their own country or across international borders, often under conditions of considerable uncertainty and insecurity. During displacement, people may experience overcrowding, inadequate shelter, poor sanitation, limited access to food and clean water, and increased exposure to infectious diseases.

Displacement can also interrupt ongoing medical treatment and separate patients from their usual healthcare providers. Individuals may lose medical documentation, prescriptions, or access to medicines that are essential for controlling chronic conditions. Language barriers, administrative difficulties, financial limitations, and unfamiliar healthcare systems can create additional obstacles when displaced populations attempt to obtain care in new locations.

The health needs of displaced populations are not static but evolve throughout the different stages of displacement. During the initial emergency, priorities may include protection from

immediate danger, access to safe shelter, food and water, emergency medical assistance, and the treatment of acute injuries or infections. As displacement continues, healthcare needs become increasingly complex and require more stable and comprehensive services.

Longer-term priorities often include continuity of primary healthcare, management of chronic diseases, maternal and child health services, vaccination, rehabilitation, and mental health support. Individuals who have experienced violence, separation from family members, loss of housing, or prolonged uncertainty may require psychological and social assistance. Mental health needs should therefore be integrated into humanitarian healthcare planning rather than treated as an isolated or secondary concern.

Rehabilitation is another essential component of care, particularly for individuals who have sustained traumatic injuries, undergone major surgical procedures, or developed physical disabilities. Access to rehabilitation services, assistive devices, and long-term follow-up can significantly influence functional recovery, independence, and quality of life. However, these services may receive insufficient attention when humanitarian responses focus primarily on immediate survival.

The consequences of displacement also extend to the healthcare systems of receiving communities. Sudden increases in population may place additional pressure on hospitals, primary care services, vaccination programmes, and public health infrastructure. Effective responses should therefore aim to strengthen local healthcare capacity while ensuring that displaced individuals and host populations can access appropriate services without discrimination.

Financial hardship and social exclusion may further complicate access to healthcare. Displaced people may have limited employment opportunities, insufficient financial resources, or uncertain legal and administrative circumstances. These barriers can delay medical consultations, interfere with treatment adherence, and contribute to preventable deterioration in health. Humanitarian health strategies must therefore consider not only clinical needs but also the social and economic conditions that influence the ability to receive care.

Addressing these complex challenges requires coordination among healthcare institutions, humanitarian organizations, public health authorities, and local communities. Emergency medical assistance remains essential, but isolated interventions are insufficient when the consequences of conflict persist over time. Sustainable responses should seek to maintain essential services, strengthen existing healthcare structures, support the workforce, and progressively restore the capacity of affected communities to manage their own health needs.

Long-term planning is particularly important during the transition from emergency response to recovery. Rebuilding healthcare facilities, restoring vaccination programmes, strengthening laboratory services, re-establishing medicine supply chains, and supporting the education and

retention of healthcare professionals are essential steps toward restoring effective healthcare delivery.

International cooperation can contribute by facilitating the exchange of expertise, providing technical and material support, and strengthening partnerships with local healthcare professionals. However, external assistance should be coordinated with existing institutions and adapted to the needs and priorities identified by affected communities. The objective should not be limited to delivering temporary services, but should also include supporting the recovery and long-term resilience of local healthcare systems.

Ultimately, the health consequences of armed conflict demonstrate how closely healthcare depends on social stability, functioning institutions, adequate infrastructure, and access to essential resources. Protecting population health during humanitarian crises requires more than treating injuries or responding to infectious disease outbreaks. It requires maintaining continuity of care, protecting vulnerable populations, addressing the changing needs of displaced people, and supporting the reconstruction of healthcare systems.

From a global health perspective, an effective response to conflict must combine immediate humanitarian assistance with sustained investment in healthcare access, professional capacity, rehabilitation, and long-term recovery. Strengthening these components is essential for reducing preventable illness and death, protecting human dignity, and ensuring that populations affected by conflict are not excluded from essential healthcare services [37].

Care standards under resource pressure

Providing healthcare during armed conflicts, humanitarian emergencies, and large-scale population displacement presents major clinical, organizational, and ethical challenges. Healthcare professionals are often required to work in unstable environments characterized by shortages of essential medicines, medical equipment, qualified personnel, and functioning healthcare facilities. Under these circumstances, maintaining appropriate standards of care can be extremely difficult. Nevertheless, humanitarian healthcare must remain guided by fundamental principles of humanity, impartiality, respect for human dignity, and professional responsibility.

The principle of humanity requires healthcare professionals and humanitarian organizations to prioritize the prevention and alleviation of suffering. Impartiality means that medical assistance should be provided according to clinical needs, without discrimination based on nationality, ethnicity, religion, political affiliation, social status, or other characteristics unrelated to healthcare requirements. These principles are particularly important during conflicts, when social divisions, insecurity, and limited resources may increase the risk of unequal access to essential services.

Scarcity of healthcare resources can create situations in which clinical teams are unable to provide every patient with the level of care that would normally be available in a well-resourced healthcare system. Hospitals may lack sufficient operating theatres, intensive care beds, oxygen supplies, blood products, or essential medicines. Healthcare professionals may therefore have to make difficult decisions about the prioritization of treatment and the allocation of available resources.

Triage becomes particularly important under these conditions. Its purpose is to identify patients according to the urgency of their clinical needs and the potential benefits of available interventions. In mass-casualty incidents or other situations where demand exceeds available capacity, triage may also require consideration of how limited resources can be used to provide the greatest possible clinical benefit.

Such decisions must be based on transparent, clinically justified, and consistently applied criteria. Healthcare teams should establish appropriate prioritization procedures whenever possible, ensuring that decisions are informed by clinical severity, urgency, anticipated treatment benefit, and the resources actually available. These procedures should be regularly reassessed as patient conditions, staffing levels, and available supplies change.

Importantly, resource limitations do not justify discrimination or arbitrary decision-making. Difficult allocation decisions should not be influenced by personal preferences, social status, or characteristics unrelated to clinical need. When several patients have comparable clinical needs and resources remain insufficient, institutions should adopt fair and ethically defensible decision-making processes. Clear documentation and appropriate review can help improve consistency, accountability, and trust.

The implementation of clinical protocols in humanitarian settings also requires careful adaptation. Recommendations developed for highly resourced healthcare environments may depend on diagnostic technologies, specialist personnel, or treatments that are unavailable during emergencies. Applying such protocols without considering local conditions may result in unrealistic expectations, delays in treatment, or inefficient use of scarce resources.

Clinical guidance should therefore be sufficiently clear and practical to support decision-making under difficult circumstances, while remaining flexible enough to accommodate local epidemiology, available expertise, and supply constraints. Adaptation should preserve essential principles of patient safety and evidence-informed care, rather than simply accepting lower standards as an unavoidable consequence of limited resources.

For example, when advanced diagnostic investigations are unavailable, clinical assessment and basic laboratory testing may assume greater importance. Similarly, when specialist services are limited, clear referral pathways and appropriate stabilization procedures can help improve the

management of patients requiring more complex treatment. These adaptations should be developed with the participation of local healthcare professionals, who are best positioned to understand the practical limitations and needs of their working environment.

Professional safety is another essential consideration. Healthcare workers operating in conflict-affected or unstable environments may face physical danger, psychological stress, excessive workloads, and increased exposure to infectious diseases. Protecting healthcare personnel is not only a professional and ethical obligation, but also a necessary condition for maintaining continuity of medical services.

Healthcare organizations should therefore seek to provide appropriate protective equipment, infection prevention measures, security procedures, psychological support, and reasonable working arrangements whenever circumstances permit. Protecting personnel also requires recognizing the limits of what individuals can safely accomplish in environments where institutional support and essential resources are inadequate.

Informed consent and respect for patient autonomy should remain central to humanitarian healthcare. Emergency conditions may complicate communication and decision-making, particularly when patients are critically ill, displaced, or unable to communicate in the same language as healthcare professionals. Nevertheless, patients should receive understandable information about their condition and proposed treatment whenever possible, and their preferences should be respected within the limits of applicable ethical and legal requirements.

Communication must also take account of cultural differences, psychological distress, and the circumstances experienced by people affected by violence or displacement. Patients should be treated as individuals with rights, values, and personal histories, rather than simply as recipients of emergency assistance.

International collaboration can provide valuable support to healthcare professionals working under resource pressure. Remote consultations, online educational activities, and communication between healthcare institutions may facilitate access to specialist expertise and support difficult clinical decisions. These approaches can be particularly useful when local services are isolated or when the movement of healthcare professionals is restricted.

However, remote collaboration must be organized responsibly. The exchange of clinical information should respect patient confidentiality, data protection requirements, and the security of both patients and healthcare workers. In conflict-affected environments, the inappropriate disclosure of personal or institutional information may create additional risks. Digital tools should therefore be used only when their potential benefits justify the associated privacy and security considerations.

External support should also aim to strengthen existing healthcare services rather than replace local decision-making. International partners can contribute through professional education, technical assistance, essential medical supplies, and the development of practical clinical resources. However, interventions should be planned in cooperation with local professionals and institutions, taking account of available infrastructure and the possibility of maintaining activities after external assistance has ended.

Introducing complex procedures that depend on equipment, medicines, or specialist expertise that cannot be reliably maintained may provide only temporary benefits. Sustainable humanitarian cooperation should instead prioritize interventions that are clinically valuable, feasible, and capable of strengthening local healthcare capacity over time.

Continuous professional education remains important even during emergencies. Training in triage, infection prevention, emergency stabilization, communication, and ethical decision-making can help healthcare teams respond more consistently to difficult situations. Multidisciplinary discussions and the review of challenging clinical cases may also support shared understanding and improve the quality of decisions.

Healthcare institutions should document major resource limitations and their consequences whenever feasible. Identifying shortages of medicines, diagnostic equipment, staff, or essential infrastructure can help explain clinical difficulties, guide requests for assistance, and support future planning. Documentation should be proportionate to the circumstances and should not divert personnel from urgent patient care.

Ultimately, maintaining appropriate standards of care in humanitarian emergencies requires a balance between clinical necessity, ethical responsibility, and operational feasibility. Healthcare professionals may be required to make difficult decisions under conditions of profound uncertainty, but these circumstances do not remove the obligation to act fairly, communicate transparently, and protect human dignity.

From a global health perspective, the objective should be to support healthcare systems in delivering the safest and most effective care possible while progressively reducing the inequalities that make resource scarcity particularly harmful. International solidarity is meaningful when it helps overcome practical barriers, strengthens local professional capacity, and ensures that populations affected by conflict and humanitarian crises receive care based on their needs and fundamental rights.

Conflict and antimicrobial resistance

Armed conflicts and humanitarian emergencies can create conditions that increase the risk of infectious complications and facilitate the emergence and spread of antimicrobial-resistant

microorganisms. The relationship between conflict and AMR is complex and involves several interconnected factors, including traumatic injuries, disruption of healthcare services, inadequate infection prevention and control, limited diagnostic capacity, inappropriate or interrupted antimicrobial treatment, and population displacement. These factors may act simultaneously, increasing the vulnerability of affected populations and placing additional pressure on already fragile healthcare systems [38, 39].

Traumatic injuries represent an important component of this relationship. Conflict-related wounds are frequently associated with extensive tissue damage, contamination with environmental microorganisms, and delayed access to appropriate medical or surgical treatment. Open fractures, severe soft-tissue injuries, burns, and other complex wounds may require repeated surgical procedures, prolonged hospitalization, and extended antimicrobial treatment. When adequate surgical facilities, sterile equipment, and trained personnel are unavailable, the risk of infectious complications may increase substantially [38].

The management of these injuries often requires a multidisciplinary approach involving surgeons, infectious disease specialists, microbiologists, nurses, and rehabilitation professionals. Appropriate wound cleaning, removal of nonviable tissue, drainage of infected collections, and other necessary source-control procedures are essential components of infection management. Antimicrobial therapy should support these interventions rather than replace them, since antibiotics alone may be insufficient when an infected focus has not been adequately controlled.

In conflict-affected healthcare facilities, these essential measures may be difficult to implement consistently. Damage to hospitals, shortages of surgical supplies, interruptions in electricity or water services, and insufficient staffing can compromise the safety of clinical procedures. Overcrowding and prolonged hospitalization may further increase opportunities for healthcare-associated transmission of resistant microorganisms, particularly when infection prevention measures cannot be maintained [38, 40].

Infection prevention and control therefore plays a central role in limiting the spread of resistant pathogens in humanitarian settings. Basic interventions, including hand hygiene, environmental cleaning, appropriate wound care, safe invasive procedures, and transmission-based precautions when indicated, remain essential even under conditions of severe resource limitation. However, the effectiveness of these measures depends on reliable access to clean water, disinfectants, protective equipment, and adequately trained healthcare personnel.

When these resources are insufficient, healthcare teams may struggle to maintain recommended infection prevention standards. Patients requiring complex wound management or prolonged hospitalization may consequently face increased exposure to healthcare-associated infections. Resistant organisms such as Acinetobacter baumannii, Klebsiella pneumoniae, and Pseudomonas

aeruginosa are of particular concern because they can cause difficult-to-treat infections, especially among severely injured or critically ill patients. Nevertheless, the relative importance of individual pathogens varies considerably between settings and should be assessed through local microbiological surveillance whenever possible [38, 39].

Limited diagnostic capacity represents another major challenge. Microbiology laboratories may be damaged, inaccessible, or unable to operate because of shortages of reagents, equipment, electricity, and trained personnel. Without reliable bacterial identification and antimicrobial susceptibility testing, clinicians may have insufficient information to determine which microorganisms are responsible for an infection and which antibiotics are likely to be effective.

In these circumstances, broad-spectrum antimicrobial therapy may be necessary when patients present with severe infections and microbiological information is unavailable. However, prolonged or unnecessary exposure to broad-spectrum antibiotics can increase selective pressure and contribute to the emergence and persistence of resistant microorganisms. This creates a difficult clinical balance between the immediate need to provide effective treatment and the longer-term responsibility to preserve antimicrobial effectiveness [38, 40].

Disruptions in antimicrobial supply chains can further complicate treatment. Essential antibiotics may become unavailable because of damaged transportation networks, restrictions on the movement of medical supplies, interruptions in procurement, or the deterioration of pharmaceutical distribution systems. These shortages may force clinicians to use alternative agents that are less appropriate for the suspected infection or to modify treatment according to availability rather than clinical indications.

Irregular access to antibiotics may also contribute to incomplete treatment courses, inappropriate substitutions, or the use of medicines obtained through poorly regulated distribution channels. However, it is important to recognize that insufficient access to effective antibiotics and excessive antimicrobial consumption are distinct problems that may coexist in the same humanitarian setting. Both can undermine patient care and contribute to the broader challenges associated with AMR [39, 40].

Antimicrobial stewardship in conflict-affected environments must therefore be adapted to local realities. Its objective should not simply be to reduce antibiotic prescribing, but to support appropriate treatment decisions while ensuring that patients with serious bacterial infections receive effective therapy without unnecessary delay. Practical stewardship measures may include standardized treatment recommendations, regular clinical reassessment, appropriate antimicrobial dosing, documentation of treatment decisions, and adaptation of therapy according to microbiological findings whenever these are available.

The movement of populations during armed conflict introduces additional challenges. Displaced individuals may experience interrupted medical treatment, overcrowded living conditions, limited sanitation, and reduced access to healthcare services. Patients who have received treatment in several healthcare facilities may also have been exposed to different microorganisms and antimicrobial prescribing practices. These circumstances can complicate infection prevention and the continuity of appropriate treatment.

Population displacement may contribute to the movement of antimicrobial-resistant microorganisms between healthcare institutions and geographical regions. However, this relationship must be interpreted carefully. The presence of resistant organisms among displaced populations does not imply that displacement itself is the principal cause of resistance, nor should displaced individuals be stigmatized as sources of infection. Resistant microorganisms circulate in many healthcare and community settings, and their transmission is influenced by multiple environmental, clinical, and organizational factors [38, 39].

The appropriate response is therefore to strengthen infection prevention, improve access to diagnosis and treatment, and ensure continuity of care for all patients. Healthcare institutions receiving individuals transferred from conflict-affected settings should use proportionate, risk-based infection prevention procedures that protect patients without creating unnecessary barriers to healthcare.

Environmental damage caused by conflict may also influence infectious disease risks. Destruction of water and sanitation infrastructure, inadequate waste management, contamination of living environments, and disruption of agricultural activities can increase exposure to infectious agents. These conditions may contribute indirectly to antimicrobial resistance by increasing the occurrence of infections requiring antibiotic treatment and creating environments in which resistant microorganisms can circulate [39].

Nevertheless, the relative contribution of each factor remains difficult to determine. Conflict-related AMR is influenced by local epidemiology, pre-existing resistance patterns, the duration and intensity of conflict, healthcare capacity, population movements, and access to antimicrobial agents. It would therefore be scientifically inappropriate to attribute the emergence or spread of resistance to a single mechanism or to assume that all conflict-affected regions experience the same patterns of antimicrobial resistance [38, 39].

Addressing these challenges requires coordinated interventions that integrate clinical care, infection prevention, diagnostic services, antimicrobial stewardship, and public health surveillance. Even in resource-limited settings, practical improvements may be achieved by establishing clear wound-management protocols, strengthening basic hygiene measures, promoting appropriate antimicrobial prescribing, and improving communication between healthcare professionals.

Maintaining microbiological capacity is particularly important. Where comprehensive laboratory services cannot be restored immediately, collaboration with regional laboratories, referral facilities, or mobile diagnostic services may help provide essential bacterial identification and susceptibility testing. Such arrangements should be designed according to logistical feasibility, specimen transport requirements, quality assurance standards, and the security conditions affecting healthcare operations [40].

Multidisciplinary professional networks can contribute by sharing clinical experience, providing educational resources, supporting laboratory training, and developing practical guidance for the management of complicated infections. Remote consultation may also help clinicians discuss difficult cases and access specialist advice when local expertise is limited. However, these activities must respect patient confidentiality, data protection requirements, and the safety of healthcare professionals working in insecure environments.

International cooperation should focus on strengthening locally led responses rather than introducing interventions that cannot be maintained under existing conditions. Local healthcare professionals possess essential knowledge of disease patterns, available resources, cultural circumstances, and operational constraints. Their participation in identifying priorities, designing interventions, and evaluating outcomes is therefore indispensable for developing effective and sustainable strategies [39, 40].

External partners can provide valuable support through essential medical supplies, diagnostic resources, professional training, and technical assistance. Nevertheless, cooperation should be organized to reinforce existing healthcare institutions and support continuity of care beyond the immediate emergency. Educational programmes should emphasize practical competencies that healthcare teams can apply within their working environment, including wound assessment, infection prevention, appropriate antimicrobial treatment, microbiological sampling, and recognition of complications.

Long-term recovery also requires attention to the rebuilding of healthcare infrastructure, restoration of laboratory services, strengthening of pharmaceutical supply chains, and development of surveillance systems capable of monitoring antimicrobial resistance. These measures are important not only for managing infections associated with traumatic injuries, but also for improving the prevention and treatment of infectious diseases across the wider population [39, 40].

Ultimately, antimicrobial resistance in conflict-affected settings illustrates how infectious disease risks are closely connected to the stability and functioning of healthcare systems. Armed conflict can create conditions that increase the occurrence of infections, complicate their diagnosis and treatment, and facilitate the transmission of resistant microorganisms. However, these consequences are not inevitable and can be mitigated through effective infection prevention, access to

appropriate antimicrobial therapy, essential diagnostic services, and sustained healthcare support.

From a global health perspective, addressing AMR during humanitarian emergencies requires a balance between immediate clinical priorities and long-term health system strengthening. Protecting patients with traumatic injuries, preventing healthcare-associated infections, ensuring equitable access to effective antibiotics, and supporting local healthcare professionals are complementary elements of the same strategy. Sustainable progress depends on recognizing the complex relationship between conflict and antimicrobial resistance while promoting practical, coordinated, and context-sensitive interventions that protect vulnerable populations and strengthen healthcare resilience [33, 34, 35]. [41, 42]

Beyond emergency deployment

Partnerships should plan for the period after the immediate crisis. Rehabilitation, training replacement staff, rebuilding surveillance and restoring primary care are long-term tasks. An equitable recovery agenda gives affected communities influence over priorities and funding, and makes capacity transfer more important than short-lived visibility.

International solidarity is more effective when emergency support strengthens existing institutions. Short-term expert deployments may be necessary, but they should be coordinated with local services, produce transferable knowledge and avoid replacing local decision-makers. Partnerships that continue after the emergency can support supply recovery, workforce education and the rebuilding of referral systems. Such continuity is particularly important when attention moves elsewhere before the effects of crisis have resolved.

Key messages

- Protect continuity of emergency, maternal, surgical, infectious-disease and chronic care during conflict and displacement.
- Plan for rehabilitation, mental health, displaced populations and recovery beyond the first emergency response.
- Adapt clinical delivery to constrained conditions without abandoning impartiality, professional ethics or safety.
- Support local health professionals and community leadership rather than relying only on short external deployments.

10
Technology, artificial intelligence and responsible innovation

Innovation must answer a defined need

Digital technologies, telemedicine, and artificial intelligence (AI) are increasingly influencing the organization and delivery of healthcare services. These innovations offer important opportunities to improve access to medical expertise, support clinical decision-making, strengthen disease surveillance, and facilitate communication between healthcare professionals working in different geographical locations. In global health, their potential is particularly relevant because they may help overcome some of the barriers associated with geographical isolation, shortages of qualified personnel, and unequal access to specialized healthcare services.

However, technological innovation does not automatically lead to better healthcare. The introduction of digital systems may also reinforce existing inequalities when access to technology, internet connectivity, digital infrastructure, and professional training is unevenly distributed. Healthcare institutions in well-resourced settings may benefit from advanced digital platforms and artificial intelligence applications, while facilities in underserved regions may continue to face difficulties obtaining reliable electricity, basic diagnostic equipment, or stable internet connections.

For this reason, responsible innovation should begin with a clear understanding of the healthcare problem that needs to be addressed. The availability of a new technology should not be considered sufficient justification for its implementation. Instead, healthcare professionals and institutions should first identify an unmet clinical, organizational, or educational need and determine whether a technological intervention can provide a meaningful improvement compared with existing approaches.

Telemedicine provides a useful example of how digital innovation can improve healthcare access when it responds to a specific need. Patients living in rural or remote communities may face considerable difficulties reaching hospitals or consulting specialist physicians. Telemedicine can facilitate remote consultations, support clinical follow-up, and allow healthcare professionals working in smaller facilities to obtain advice from specialists based elsewhere.

Nevertheless, the effectiveness of telemedicine depends on several practical conditions. Patients and healthcare professionals must have access to appropriate communication devices, reliable connectivity, and sufficient digital literacy. Healthcare organizations must also establish clear

procedures for clinical assessment, documentation, patient confidentiality, and referral when an in-person examination or urgent intervention is required.

In some settings, a simple and reliable communication system may provide greater practical benefits than a technologically sophisticated platform. For example, a low-bandwidth referral system that allows district hospitals to share essential clinical information with specialist centres may improve access to expert advice without requiring expensive infrastructure. By contrast, a complex digital system that depends on continuous high-speed internet access may be unsuitable for facilities where connectivity is unreliable.

These considerations demonstrate that the value of innovation depends on its ability to function effectively in the environment where it is introduced. Technological complexity should not be confused with clinical usefulness. A relatively simple intervention that addresses a clearly identified problem may produce greater benefits than an advanced system that is difficult to maintain or integrate into everyday healthcare practice.

Artificial intelligence introduces additional opportunities and challenges. AI-based applications may support the interpretation of medical images, analysis of clinical information, identification of patterns in large datasets, and development of decision-support systems. They may also contribute to public health surveillance, resource planning, and professional education. However, the potential benefits of these applications must be assessed through appropriate scientific evaluation rather than assumed from their technical capabilities.

A central concern is the quality and representativeness of the data used to develop AI systems. Algorithms trained primarily on information from particular countries, healthcare institutions, or population groups may perform less reliably when applied to different settings. Differences in disease prevalence, demographic characteristics, clinical practices, diagnostic resources, and data collection methods can influence the accuracy and usefulness of automated predictions.

For example, an AI system developed using data from well-resourced hospitals may not perform equally well in healthcare facilities where diagnostic investigations are less frequently available or medical records contain different types of information. Similarly, models trained on populations that do not adequately represent the diversity of intended users may produce systematically different error rates across patient groups.

These limitations raise important questions concerning equity and patient safety. A technology intended to reduce disparities in healthcare could unintentionally increase them if its performance is less reliable among populations that already face barriers to accessing medical services. Consequently, AI applications should be evaluated in the populations and healthcare environments where they are expected to operate, with particular attention to differences in performance and potential unintended consequences.

Clinical validation is therefore essential before introducing digital decision-support systems into routine practice. Evaluation should establish whether a technology performs its intended function accurately, whether its predictions are appropriately calibrated, and whether its use leads to improvements in clinically relevant outcomes. Technical performance alone is insufficient. A system may demonstrate high accuracy under controlled research conditions without producing meaningful benefits when used by healthcare professionals in real clinical environments.

The assessment of digital innovation should also consider how the proposed technology interacts with existing clinical workflows. Healthcare professionals must understand when and how to use the system, how to interpret its outputs, and when additional clinical assessment is necessary. If a technology introduces unnecessary complexity, increases documentation requirements, or disrupts communication between professionals, its implementation may create new difficulties rather than resolve existing problems.

Safety and accountability are particularly important when digital tools influence clinical decisions. AI-generated recommendations may contain errors, reflect limitations in training data, or fail to account for relevant aspects of an individual patient's condition. Healthcare professionals should therefore remain able to critically assess technological outputs and integrate them with clinical findings, professional expertise, and patient preferences.

Human oversight should be meaningful rather than purely formal. This requires appropriate training, sufficient information about the limitations of the technology, and clear institutional procedures for identifying and responding to errors. Responsibility for clinical decisions must remain clearly defined, particularly when automated systems contribute to diagnosis, treatment selection, or prioritization of healthcare resources.

Privacy and data protection represent further essential considerations. Digital health technologies frequently rely on the collection, storage, and analysis of sensitive personal information. Healthcare institutions must ensure that data are processed responsibly, that access is appropriately controlled, and that patients are informed about relevant uses of their information in accordance with applicable ethical and legal requirements.

These considerations become especially important in international collaborations, where healthcare data may be shared across institutions operating under different regulatory frameworks. Data governance arrangements should clarify responsibilities, access permissions, security safeguards, and the conditions under which information may be used for research or clinical purposes.

The economic sustainability of digital innovation must also be evaluated carefully. The initial acquisition cost of a technology represents only one component of its total financial impact.

Additional resources may be required for staff training, software updates, technical maintenance, equipment replacement, cybersecurity, and ongoing evaluation of performance.

In healthcare settings with limited resources, these costs may influence whether an intervention can be maintained over time. A digital system that performs well during a short pilot project may become ineffective if external funding ends or technical support is no longer available. Sustainable implementation therefore requires realistic financial planning and consideration of the institution's long-term capacity to operate and maintain the technology.

Accessibility is another essential dimension. Digital healthcare services should be designed to accommodate individuals with different levels of education, digital literacy, language proficiency, and physical ability. Patients who lack personal devices, reliable internet access, or familiarity with digital platforms may be excluded from services that are intended to improve healthcare access. For this reason, digital transformation should not result in the disappearance of essential non-digital healthcare pathways. Alternative forms of access may remain necessary to protect patients who cannot use digital services or whose clinical needs require direct professional assessment.

The introduction of new technologies should also involve healthcare professionals and communities from the earliest stages of development and implementation. Local participation can help identify practical needs, cultural considerations, organizational barriers, and potential unintended effects that may not be apparent to technology developers working outside the intended healthcare setting.

International collaboration can support the responsible development and evaluation of digital health technologies by facilitating the exchange of scientific knowledge, methodological expertise, and implementation experience. However, these partnerships should promote equitable participation rather than treating institutions in less-resourced settings simply as sources of data or potential markets for technological products.

Local professionals should have meaningful opportunities to contribute to defining research questions, evaluating performance, adapting technological systems, and determining whether a proposed intervention is appropriate for their communities. Such participation can improve the relevance of innovation while strengthening local capacity for technological assessment and independent decision-making.

Ultimately, successful healthcare innovation should be measured by its contribution to patient care, professional practice, and population health rather than by its technological sophistication. The most valuable digital tools are those that address clearly identified needs, demonstrate reliable performance, support healthcare professionals, and remain accessible and sustainable within the settings where they are used.

From a global health perspective, digital technologies and artificial intelligence have the potential to improve the exchange of knowledge and extend access to essential healthcare services across geographical boundaries. Realizing this potential requires rigorous scientific evaluation, responsible governance, protection of patient rights, and sustained attention to equity.

Innovation should therefore be understood as a means of strengthening healthcare systems rather than an objective in itself. Its ultimate purpose is to support safer clinical decisions, improve access to appropriate care, reduce avoidable inequalities, and contribute to better health outcomes for populations worldwide [39, 40].

The role of clinical and community oversight

The increasing use of artificial intelligence in healthcare raises important questions concerning clinical responsibility, patient safety, transparency, and public trust. Although AI-based systems can support healthcare professionals by analyzing complex information, identifying patterns, and generating recommendations, their outputs should always remain subject to critical evaluation. The use of artificial intelligence must not weaken professional accountability or reduce the importance of clinical judgment in decisions that may directly affect patient health and well-being.

Human oversight is therefore an essential requirement for the responsible implementation of AI in healthcare. However, meaningful oversight involves more than simply ensuring that a healthcare professional formally approves an automated recommendation. Clinicians must have sufficient knowledge, training, and time to understand the intended purpose of a system, recognize its limitations, and critically assess whether its outputs are appropriate for the individual patient and clinical circumstances.

Healthcare professionals should be informed about how an AI system was developed and evaluated, the characteristics of the data used for its training, and the populations and clinical settings in which its performance has been tested. They should also understand the level of uncertainty associated with its predictions and the circumstances in which its recommendations may be unreliable. This information is essential for avoiding excessive reliance on automated outputs and ensuring that technological assistance remains consistent with evidence-based clinical practice.

A particular concern is the possibility of automation bias, which occurs when individuals place excessive confidence in computer-generated recommendations, even when other available information suggests that those recommendations may be incorrect. In healthcare, this may lead professionals to overlook relevant clinical findings or accept inaccurate predictions without sufficient verification. Appropriate education, clear communication of system limitations, and the preservation of independent clinical assessment can help reduce this risk.

Healthcare institutions also have a responsibility to establish clear governance procedures before introducing AI-based systems into routine practice. These procedures should define the intended clinical use of each technology, the professionals responsible for supervising its operation, and the processes for identifying and managing potential errors. Responsibilities should be clearly assigned among healthcare providers, institutional leadership, technology developers, and other relevant stakeholders, according to their respective roles and applicable regulatory requirements.

The evaluation of AI systems should continue after their introduction into clinical practice. Performance observed during initial testing may change over time because of differences in patient populations, clinical practices, data quality, or updates to the underlying technology. Continuous monitoring is therefore necessary to determine whether a system remains accurate, safe, and useful in the healthcare environment where it is being applied.

Institutions should develop procedures for reporting incidents, investigating unexpected outputs, and responding to situations in which an AI system may have contributed to an incorrect or potentially harmful decision. These mechanisms should encourage the identification of problems and support continuous improvement. When significant safety concerns arise, healthcare organizations must also be able to restrict, suspend, or discontinue the use of a technological function until its reliability has been adequately reassessed.

Transparency is particularly important when AI systems influence decisions related to diagnosis, treatment, screening, or the allocation of healthcare resources. Healthcare professionals should have access to sufficient information to understand the basis and limitations of automated recommendations, even when the underlying computational processes are complex. The inability to explain every technical aspect of an algorithm does not remove the obligation to evaluate its performance, communicate relevant uncertainty, and establish appropriate safeguards.

Equity must also be considered throughout the development, evaluation, and implementation of AI technologies. Systems trained on data that do not adequately represent the populations in which they will be used may produce different levels of accuracy across demographic, geographical, or socioeconomic groups. Such differences can become particularly harmful when automated outputs influence access to diagnostic investigations, specialist consultations, or essential healthcare services.

Responsible evaluation should therefore examine whether a technology performs consistently across relevant patient populations and whether its implementation creates new barriers to care. Differences in digital literacy, language, disability, internet access, and healthcare infrastructure may influence who can benefit from technological innovation. Monitoring should identify these inequalities and support appropriate modifications before they contribute to avoidable harm.

Community participation is another important component of responsible AI governance, particularly when digital systems are used in population screening, public health surveillance, or decisions affecting access to healthcare. Patients and communities should receive understandable information about the purpose of these technologies, the types of data collected, the potential benefits and limitations of their use, and the safeguards established to protect privacy and individual rights.

Participation should extend beyond the passive acceptance of technologies developed by external institutions. Patients, healthcare professionals, and community representatives can provide valuable perspectives on the acceptability, accessibility, and potential consequences of AI-supported services. Their involvement in consultation, evaluation, and feedback processes can help identify concerns that may otherwise remain unnoticed.

This approach is particularly relevant in global health, where technological systems may be introduced into healthcare environments with different cultural expectations, regulatory frameworks, and levels of available resources. Responsible implementation requires sensitivity to these differences while maintaining consistent commitments to patient safety, human dignity, and equitable access to healthcare.

The World Health Organization has emphasized that the development and use of artificial intelligence in health should be guided by ethical principles, the protection of human rights, transparency, accountability, and the promotion of public benefit. These considerations reinforce the importance of ensuring that technological innovation serves the needs of patients and communities rather than allowing technological capabilities alone to determine healthcare priorities [40].

Ultimately, artificial intelligence should be understood as a tool for supporting healthcare professionals and strengthening health systems, not as a substitute for human responsibility. Its successful integration into healthcare depends on rigorous evaluation, continuous monitoring, meaningful professional oversight, and the active involvement of the communities affected by its use.

From a global health perspective, responsible AI governance is essential for ensuring that technological progress contributes to safer clinical decisions, more equitable access to healthcare, and greater public confidence in scientific innovation. The ultimate measure of success is not the extent to which automated systems replace human activities, but their ability to improve healthcare while preserving professional accountability, patient autonomy, and fundamental human rights.

A cross-border digital commons

Accessible educational materials, interoperable standards and appropriately governed data collaborations can reduce duplication. However, open access is not equivalent to unrestricted access

to personal health information. Data sharing must account for consent, security, fair benefit, national rules and potential misuse.

Cross-border educational collaboration can benefit from shared vocabularies, transparent methods and interoperable formats. However, health data can expose individuals and communities to serious risks when used outside the purpose for which they were collected. Governance should establish who may access data, what questions are permitted, how consent and legal obligations are addressed, and how participating institutions share in the value generated. Fairness includes the possibility to decline a proposed use without losing the opportunity to cooperate in other ways.

A borderless network should create opportunities for institutions with limited computational resources to evaluate and question tools, rather than merely supplying data to developers elsewhere. Shared assessment methods and training in critical appraisal are as important as distributing software.

Figure 7 illustrates a practical framework for introducing digital technologies into global health systems in a responsible, equitable, and sustainable manner. The central message is that technological innovation should be driven by real healthcare needs rather than by the availability or novelty of digital tools. Successful innovation requires a progressive process that begins with identifying a clinical, organizational, or educational problem and evaluating the local context, including available resources, digital connectivity, accessibility, infrastructure, and costs.

Once these conditions have been assessed, appropriate technologies, such as telemedicine, digital health systems, or artificial intelligence, can be selected according to their potential to address the identified need. Before widespread implementation, these tools should undergo local validation to establish their safety, clinical relevance, reliability, and effectiveness using representative data. Implementation must then be accompanied by professional oversight, continuous monitoring, feedback, and adaptation to changing circumstances and local priorities.

Figure 7 emphasizes that the ultimate objective of digital innovation is measurable health improvement, particularly safer care, better access to essential health services, and reduced inequalities between populations and healthcare systems. Throughout the entire process, four essential safeguards must be maintained: protection of patient rights and privacy, professional accountability, equity and meaningful local participation, and long-term sustainability supported by responsible data governance.

Importantly, the framework recognizes that digital technologies cannot automatically overcome structural inequalities. Without adequate infrastructure, professional training, community involvement, and sustainable financing, they may instead reinforce existing disparities. Responsible digital innovation therefore requires not only technological development but also ethical

leadership, local ownership, and continuous evaluation of its actual impact on patients and communities.

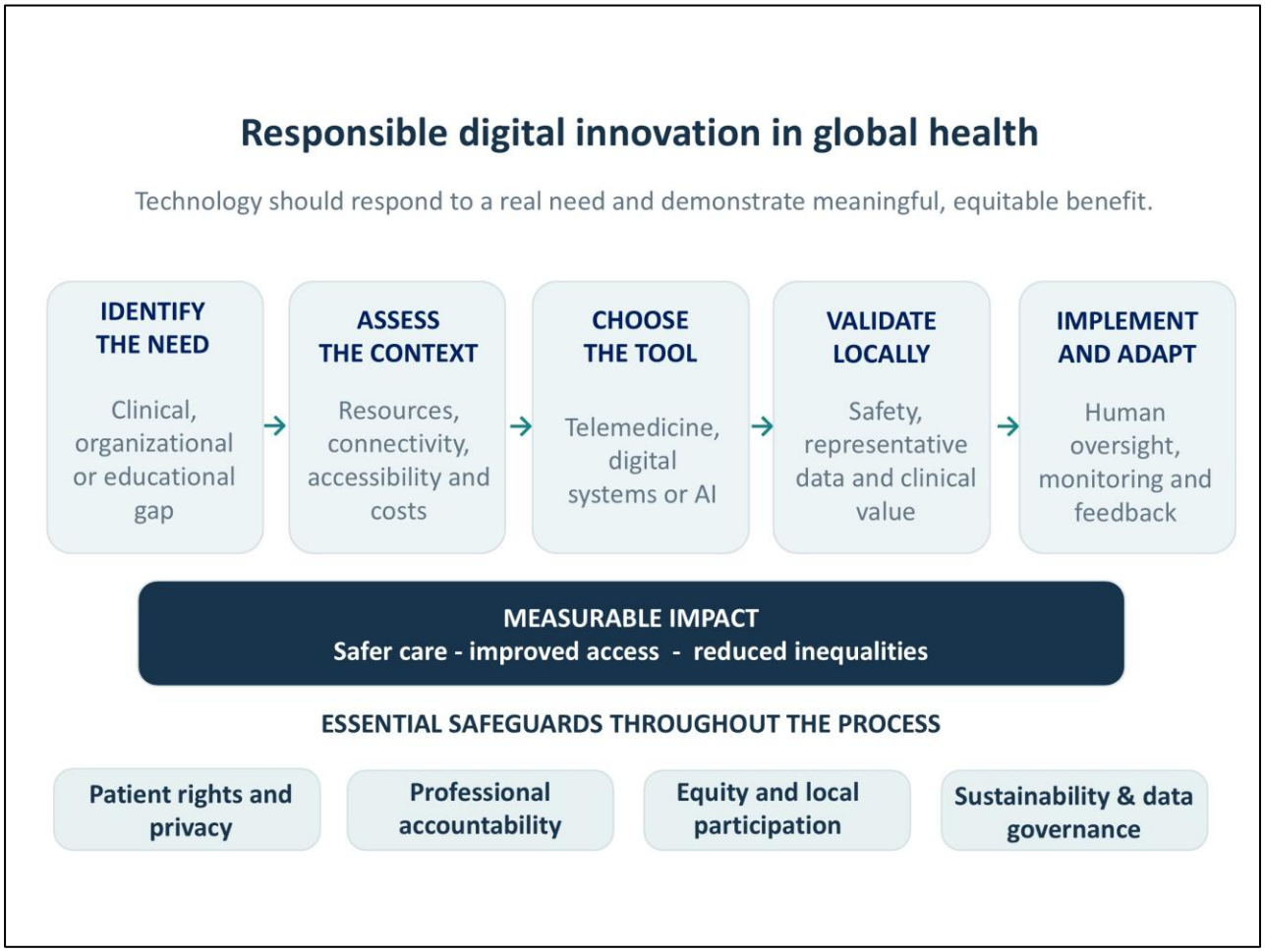


Figure 7. Responsible digital innovation in global health

Key messages

- Introduce digital tools only when they address a clear problem and have a realistic benefit for patients or services.
- Assess safety, bias, affordability, accessibility and performance in the intended setting before scaling.
- Maintain human oversight, clear responsibility, privacy protections and post-deployment monitoring for AI.
- Promote shared digital knowledge without deepening disparities in infrastructure or participation.

11
Partnerships, governance and ethical leadership

Global health diplomacy and fair access to essential medicines

Public-health challenges cross borders, but the institutions responsible for responding to them differ in mandates, resources and political accountability. Global health diplomacy can help governments, multilateral institutions, scientific societies and communities establish shared priorities, agree on responsibilities and respond to emergencies without abandoning national ownership. Multilateral institutions are most effective when their technical independence, transparent decision-making and predictable financing are protected. The sudden withdrawal of a major donor may reveal a wider structural weakness if critical programmes have become dependent on a narrow funding base.

Access to essential medicines, diagnostics and vaccines is a practical test of equitable governance. Scientific discovery does not create public-health benefit unless products are affordable, of assured quality and reliably available where they are needed. Policies on procurement, regulatory oversight, intellectual property, licensing, technology transfer and regional manufacturing can influence access; they require careful assessment of innovation incentives as well as unmet health needs. Strengthening local supply chains and professional capacity is often as important as negotiating product prices.

International agreements should therefore be judged by what they enable people and institutions to do. Transparent allocation criteria, joint procurement where appropriate, fair partnerships and safeguards against corruption can reduce avoidable disparities. A durable global-health architecture must combine international cooperation with diversified funding, local decision-making and sustained capacity to deliver essential care.

The limitations of hierarchy-based cooperation

Equitable international collaboration requires more than a shared commitment to equality. it depends on how responsibilities, resources, decision-making power, and scientific recognition are distributed among partners. In many international research and global health initiatives, institutions with greater financial resources may retain control over funding, research priorities, data ownership, authorship, and publication decisions, while local partners are primarily responsible for collecting data, recruiting participants, delivering interventions, and managing practical activities. Although these contributions are essential to the success of a project, they do not always

translate into meaningful scientific recognition, institutional development, or long-term benefits for the communities involved. Such imbalances may persist even when all participants genuinely believe they are working within an equal partnership. To prevent this situation, collaboration should be based on transparent agreements established from the beginning, clearly defining how decisions will be made, how resources will be allocated, who will have access to and responsibility for data, how authorship will reflect actual intellectual contributions, and how disagreements will be resolved. Particular attention should be given to ensuring that local institutions have a genuine role in defining research questions, interpreting findings, and deciding how results will be communicated and applied. Financial support should also strengthen local coordination, professional training, research infrastructure, and institutional capacity, so that collaboration produces benefits that continue beyond the duration of an individual project. Equally important is the recognition that scientific expertise takes different but complementary forms. Researchers may contribute methodological and statistical knowledge, clinicians working in resource-limited settings may provide essential insights into practical challenges and the feasibility of proposed interventions, and community organizations may identify social, cultural, or economic barriers that external institutions would otherwise overlook. These different contributions should be respected and integrated throughout the project, rather than considered only during implementation. Leadership should therefore reflect relevant expertise, local knowledge, and responsibility for the work, rather than institutional prestige or financial influence alone. The objective is not to distribute recognition equally regardless of contribution, but to ensure that every meaningful contribution is acknowledged fairly and that all partners have a real opportunity to influence the direction and outcomes of the collaboration. Ultimately, a genuinely equitable partnership should leave local institutions stronger, more independent, and better equipped to lead future initiatives. International cooperation achieves its greatest value when it moves beyond the simple transfer of resources or knowledge and becomes a process of mutual learning, shared responsibility, and sustainable capacity building, in which scientific progress benefits not only the institutions producing knowledge but also the professionals, health systems, and communities whose participation makes that progress possible.

A governance checklist for collaborative programmes

Before launching a project, partners should agree on the public-health need, baseline evidence, intended beneficiaries, decision rights, ethics review, expected contribution of each party, resourcing, publication policy and exit strategy. These agreements reduce misunderstandings when grants, leadership or political circumstances change.

Governance arrangements should remain understandable to the people expected to implement them. A short written agreement can identify the local objective, responsible teams, data-handling rules, dispute-resolution process and plan for sustaining useful activities. Annual or project-end reviews can ask whether power was genuinely shared and whether the intended beneficiaries experienced a change. Where several institutions are involved, a rotating chair or co-leadership model may help prevent authority from becoming fixed in the most resourced centre.

An independent mechanism for feedback can help prevent token participation. Meeting attendance is not evidence of influence. partners need realistic opportunities to change the agenda and contest decisions. Monitoring should therefore track representation in steering groups, locally led outputs and sustainability beyond external support.

Trust as an asset built through conduct

Trust develops through consistent, reliable and transparent behaviour. This means delivering promised materials, communicating difficulties without unnecessary delays, reporting setbacks honestly, acknowledging intellectual contributions, respecting agreed responsibilities, and sharing results even when outcomes are disappointing. Scientific institutions should demonstrate in their own practices the ethical standards they advocate publicly. Their credibility depends not only on scientific excellence but also on fairness, accountability and consistency between declared principles and actual decisions. Ethical governance therefore requires clear procedures, transparent financial management, responsible allocation of resources, and effective measures to prevent corruption, opaque procurement practices and conflicts of interest that may compromise scientific independence or undermine the legitimacy of health systems.

Ethical leadership also requires the willingness to listen to uncomfortable findings, acknowledge uncertainty and accept constructive criticism. Scientific and educational projects do not always achieve their expected objectives, and their results may be more limited than initially anticipated. Reporting these limitations accurately is more valuable than presenting an excessively positive interpretation simply to satisfy funders, institutional expectations or political interests. Leaders should encourage an organizational culture in which difficulties, implementation failures and unexpected outcomes can be discussed openly and used to improve future decisions. Within international scientific networks, these principles are particularly important because partners may differ in language, professional experience, institutional resources, hierarchical structures and freedom to express disagreement. Creating an environment in which all participants can contribute their perspectives without fear of exclusion or professional consequences is essential. Trust becomes stronger when critical discussion is welcomed, responsibilities are shared fairly, and

disagreement is understood as a potential contribution to scientific progress rather than a threat to institutional authority.

Long-term professional relationships can be strengthened through continuous educational exchange, mentoring opportunities, collaborative research, peer networks and jointly developed projects. These activities create opportunities for mutual learning and allow professionals from different countries and healthcare systems to understand one another's priorities, limitations and strengths. Over time, such cooperation can become less dependent on individual leaders, temporary initiatives or specific funding cycles, helping to establish more stable and resilient scientific communities. Building these relationships before emergencies arise is particularly valuable, as established networks can facilitate communication, coordinated action and knowledge sharing during health crises. However, the success of international collaboration should not be measured primarily by the number of meetings organized, publications produced or institutions represented. Its real value lies in the quality of shared decisions, the development of sustainable local capabilities, the equitable distribution of opportunities and recognition, and the measurable improvements achieved for healthcare professionals, patients and communities. Ultimately, lasting scientific trust is built when collaboration produces benefits that extend beyond the visibility, reputation or immediate interests of any single organization.

Key messages

- Define collaborative priorities jointly and distribute authority, credit and benefits transparently.
- Agree responsibilities, resources, data use, authorship and accountability at the start of each partnership.
- Assess participation by real influence on decisions and opportunities for local leadership.
- Build trust through continuity, fulfilled commitments, open feedback and sustainable institutional capacity.

12
From learning to measurable action

Designing a knowledge-to-action project

Turning scientific knowledge and general principles into practical improvements requires clear objectives, realistic planning, and local commitment. A knowledge-to-action project should begin by identifying a specific problem that can be addressed through a feasible intervention. Hospitals, educational institutions, professional networks, and community organizations can all contribute by selecting a relevant challenge, understanding the current situation, and working together to introduce meaningful changes.

The first step is to identify a problem that local professionals and communities consider important. This may involve improving infection prevention practices, strengthening healthcare education, promoting appropriate antimicrobial use, or increasing access to essential health services. The project team should examine how the problem affects daily activities, identify its main causes, and determine which factors can realistically be changed. Understanding the local context is essential because interventions that work in one setting may not be equally effective in another.

Once the problem has been defined, the team should establish a clear and achievable objective. Starting with a limited intervention is often more effective than launching a complex programme that requires substantial resources. For example, a hospital seeking to improve infection prevention could initially focus on increasing adherence to hand hygiene practices in a single department. Results could then be evaluated before extending the intervention to other areas. This gradual approach allows teams to identify difficulties, make adjustments, and build confidence in the improvement process.

Every project should have a person or team responsible for its implementation, a realistic timetable, and clearly identified resources. It should also include simple indicators to measure progress. These indicators may assess whether recommended practices are being followed, whether professional knowledge has improved, or whether the intervention has produced measurable benefits for patients and communities. Regular evaluation is necessary to understand what works, what needs improvement, and whether the results can be maintained over time.

International collaboration can provide valuable support by sharing scientific evidence, practical experience, educational materials, and technical expertise. However, successful collaboration does not mean applying the same solution everywhere. Each institution must be able to adapt

interventions to its own resources, workforce, healthcare priorities, and organizational conditions. Local professionals should remain actively involved in decision-making, ensuring that the project responds to real needs and can continue after external support has ended.

A practical knowledge-to-action project can follow a simple sequence: identify a priority problem, assess the current situation, understand the main barriers, choose an evidence-informed intervention, test it on a small scale, measure its results, and make the necessary adjustments. If the intervention proves effective and sustainable, it can be gradually expanded. If it does not produce the expected results, the experience should be used to understand the reasons and improve the approach.

An important part of this process is recognizing that improvement does not always happen immediately. Limited resources, resistance to change, organizational difficulties, and unexpected consequences may influence the results. For this reason, projects should encourage open discussion, continuous learning, and constructive feedback. An intervention that initially fails may still provide useful lessons for future initiatives.

The ultimate purpose of a knowledge-to-action project is not simply to introduce a new procedure or complete a short-term activity. It is to help institutions develop the ability to identify problems, use scientific evidence, implement appropriate solutions, and evaluate their impact independently.

Knowledge becomes truly valuable when it leads to practical, measurable, and sustainable improvements. By combining scientific evidence, local leadership, education, and international cooperation, even relatively small projects can contribute to safer healthcare, stronger institutions, and more equitable health outcomes. In this way, global collaboration moves beyond the exchange of ideas and becomes a shared commitment to meaningful action.

Choosing indicators without reducing people to numbers

Measuring progress is essential for understanding whether an intervention is making a meaningful difference. However, evaluation should not become an exercise in collecting numbers for their own sake. Indicators should be limited in number, easy to understand, feasible to collect and clearly connected to the intended benefits of a project. Their main purpose is to support learning, guide decisions and identify opportunities for improvement.

For an educational intervention, useful indicators might include the number of participants completing the programme, their ability to apply knowledge to practical situations and any subsequent changes in professional behaviour. For infection prevention and control, indicators may include adherence to hand hygiene practices, appropriate use of preventive measures and trends in healthcare-associated infections. However, these measures must always be interpreted in

relation to the local context, the reliability of the available data and the resources of the participating institution. Completing activities or reaching numerical targets does not necessarily mean that health outcomes have improved.

Every indicator should serve a practical purpose and help answer a specific question. Counting the number of healthcare professionals trained, for example, can demonstrate the reach of an educational programme, but it cannot establish whether participants have changed their clinical practice. Observing adherence to a recommended procedure may provide more useful information about behavioural change. Similarly, reductions in infection rates are important outcomes, but they may be influenced by multiple factors beyond the intervention itself. In smaller healthcare facilities, the limited number of events may also make it difficult to identify meaningful changes over short periods.

A balanced evaluation should therefore distinguish between process indicators, outcome indicators and balancing measures. Process indicators describe whether planned activities are being implemented as intended. Outcome indicators assess whether the intervention is producing the expected benefits. Balancing measures help identify unintended consequences, such as an increased workload, additional costs or reduced access to services. Considering these different dimensions together provides a more realistic understanding of progress and prevents an excessive focus on a single measure of success.

Evaluation should also be a continuous learning process rather than a final administrative requirement. Teams should periodically review their findings, discuss unexpected results and decide whether an intervention needs to be adapted. A simple discussion involving frontline professionals, supported by a small number of reliable indicators, may be more valuable than a detailed report that is never translated into action. When results are disappointing, they should be treated as opportunities to understand practical barriers and improve implementation, rather than automatically as evidence of failure.

Equity must remain a central consideration in the evaluation of global health initiatives. An intervention may appear successful when measured through overall results while leaving certain populations, institutions or geographical areas behind. Evaluation should therefore examine not only how many people benefited, but also who was reached, who remained excluded and why. Where appropriate, feasible and ethically acceptable, results can be examined according to geographical location, healthcare setting, socioeconomic conditions or other relevant characteristics.

Quantitative data should be complemented by qualitative information obtained through interviews, discussions, observations or feedback from participants and communities. These perspectives can reveal difficulties that numerical indicators alone cannot capture, including language

barriers, limited resources, cultural differences, lack of institutional support or unequal opportunities to participate.

Importantly, the value of measurement lies not in the quantity of data collected, but in its ability to improve decisions, strengthen accountability and promote more equitable outcomes. Indicators should help institutions understand whether their actions are producing real benefits while keeping the experiences, needs and dignity of people at the centre of evaluation. In global health, meaningful progress cannot be measured only by what is counted; it must also be understood through the lives and communities that interventions are intended to improve.

Key messages

- Begin each improvement project with a locally recognized problem, an accountable team and a feasible change.
- Select a small set of indicators that connect activities to decisions, outcomes and possible unintended harms.
- Use equity-sensitive data and qualitative feedback to understand who benefits and who remains excluded.
- Report unsuccessful as well as successful approaches, then adapt, sustain or discontinue based on learning.

13
An agenda for the next generation

Preparing a generation of connected professionals

Future health leaders need more than specialist technical knowledge. They must understand systems, evaluate evidence, communicate risk, collaborate across cultures and disciplines, and act ethically under constraints. These capabilities can be taught through shared case studies, exchanges, peer mentoring and projects that place learners in contact with local realities.

Professional education should include opportunities to work beyond familiar disciplinary boundaries. A surgeon may need to understand health financing and antimicrobial stewardship, while a public health practitioner may benefit from learning the constraints of emergency surgery. Students and early-career professionals can be supported through cross-country mentoring, collaborative case discussions and small supervised improvement projects. Such experiences help participants understand that a successful intervention depends on relationships as well as technical knowledge.

Young professionals should have opportunities to propose projects, moderate scientific discussion, contribute to research design and participate in governance. Their work must be supported by clear supervision and equitable recognition, not unpaid expectations that undermine accessibility.

A ten-point agenda for institutions

Addressing current and future global health challenges requires more than scientific recommendations and expressions of international solidarity. Healthcare institutions, universities, research organizations, and public health authorities must translate shared principles into practical commitments that can be implemented, evaluated, and sustained over time. A meaningful institutional agenda should therefore identify clear priorities, define responsibilities, allocate appropriate resources, and establish mechanisms for monitoring progress.

The following ten priorities provide a framework for strengthening healthcare systems, promoting equitable access to knowledge, and supporting international cooperation. Although institutions operate in different economic, social, and organizational contexts, these priorities can be adapted to local needs while preserving common commitments to scientific integrity, equity, patient safety, and sustainability.

1. Promote equitable access to education and scientific knowledge

Access to reliable scientific information and professional education should be recognized as an essential component of healthcare development. Institutions should work to reduce barriers that prevent healthcare professionals, students, and researchers from participating in educational activities or accessing current scientific evidence.

These barriers may include high educational costs, limited internet connectivity, language differences, geographical isolation, and insufficient opportunities for professional development. Practical measures may involve the development of open educational resources, multilingual teaching materials, downloadable content, low-bandwidth learning platforms, and flexible educational programmes that accommodate different working conditions.

However, expanding access should not be measured exclusively by the number of participants. Educational initiatives should also assess whether learners acquire useful competencies and can apply scientific knowledge in their professional environments. Equitable education should strengthen local expertise and support the development of sustainable healthcare capacities.

2. Ensure meaningful participation in educational and institutional governance

International cooperation becomes more effective when institutions from different countries and resource settings participate actively in defining priorities and making decisions. Healthcare organizations working in underserved regions should not be considered only as recipients of external knowledge or assistance. Their professionals possess valuable experience concerning local disease patterns, healthcare delivery, resource limitations, and practical approaches to improving services.

Institutions should therefore establish governance arrangements that encourage balanced representation and meaningful participation. This may include shared leadership responsibilities, participation in scientific and educational committees, transparent selection of project coordinators, and opportunities for professionals from different settings to contribute to strategic decisions.

Meaningful participation requires more than attendance at meetings. Partners should have the ability to influence objectives, propose activities, question decisions, and contribute to the evaluation of outcomes. Such arrangements can improve the relevance of international initiatives and promote stronger institutional ownership.

3. Protect scientific integrity and promote transparent communication

Scientific integrity is essential for maintaining public trust and ensuring that research findings can reliably inform healthcare decisions. Institutions should support ethical research practices, transparent methodologies, responsible data management, appropriate authorship criteria, and clear disclosure of potential conflicts of interest.

This commitment should extend to the publishing system itself. Institutions and funders should oppose predatory journals and paper mills, scrutinize publication incentives, recognize rigorous peer review and reproducibility, and support affordable, equitable and independent dissemination of scientific findings.

Researchers should be encouraged to communicate not only the findings of their studies but also their limitations and uncertainties. The correction of errors and the revision of conclusions in response to new evidence should be recognized as essential components of scientific progress.

Transparent communication is equally important in public health. Institutions should provide understandable information about health risks, scientific recommendations, and the reasons behind important decisions. Communication strategies should promote dialogue with healthcare professionals and communities rather than rely exclusively on the transmission of information from authorities to the public.

Institutional accountability can be strengthened through clear research policies, independent ethical review when required, accessible reporting procedures, and regular evaluation of scientific and communication practices.

4. Integrate infection prevention and antimicrobial stewardship into healthcare planning

Infection prevention and control and antimicrobial stewardship should be considered essential components of healthcare quality and patient safety. Their implementation should not depend exclusively on individual professionals or temporary initiatives but should be supported by institutional leadership, adequate resources, and continuous evaluation.

Healthcare organizations should establish multidisciplinary programmes that promote effective hand hygiene, environmental cleaning, safe invasive procedures, surveillance of healthcare-associated infections, and appropriate antimicrobial prescribing.

Stewardship programmes should support timely and effective treatment of bacterial infections while reducing unnecessary antimicrobial exposure. This requires reliable diagnostic services, access to appropriate antibiotics, regular reassessment of treatment, and collaboration among clinicians, pharmacists, microbiologists, and infection prevention professionals.

Institutions should evaluate the practical barriers that may prevent implementation, including inadequate staffing, interruptions in essential supplies, limited laboratory capacity, and insufficient professional training. Sustainable improvement depends on addressing these organizational difficulties alongside the development of clinical recommendations.

5. Strengthen preparedness for climate-related and other complex emergencies

Healthcare systems must be prepared to maintain essential services during emergencies involving infectious disease outbreaks, extreme weather events, natural disasters, and other major

disruptions. These challenges may occur simultaneously and produce consequences that are more difficult to manage than isolated events.

Institutions should assess vulnerabilities affecting healthcare infrastructure, workforce availability, electricity and water supplies, transportation networks, communication systems, and the distribution of essential medicines.

Preparedness plans should identify critical services that must remain operational, establish clear responsibilities, and provide realistic alternatives when ordinary systems become unavailable. Regular simulation exercises and practical evaluations can help healthcare teams identify weaknesses and improve coordination.

Climate adaptation should also be incorporated into routine healthcare planning. Measures such as heat-response protocols, protection of temperature-sensitive medicines, emergency transportation arrangements, and reliable backup infrastructure can improve resilience and reduce the consequences of environmental hazards.

6. Include essential surgery and emergency care in universal health coverage strategies

Access to safe, timely, and affordable surgical and emergency care is an important indicator of healthcare system performance. Many conditions requiring urgent intervention can lead to avoidable disability or death when patients cannot obtain appropriate treatment.

Healthcare planning should therefore consider the availability of essential surgical services, anaesthesia, emergency transportation, blood products, diagnostic facilities, postoperative care, and rehabilitation.

Strengthening surgical care requires attention to the complete patient pathway, from early recognition and referral to treatment and recovery. Improving district-level services, supporting appropriate workforce distribution, and establishing reliable referral networks may substantially improve access in underserved regions.

Financial protection is also essential. Patients should not be forced to delay necessary treatment or experience catastrophic financial consequences because essential surgical and emergency services are unaffordable.

Integrating these services into universal health coverage strategies can contribute to reducing inequalities while strengthening broader healthcare capacities.

7. Support ethical workforce development, professional well-being, and retention

Healthcare professionals are fundamental to the functioning and resilience of health systems. Investments in buildings, equipment, and technology cannot achieve their intended benefits without sufficient numbers of appropriately trained personnel.

Institutions should prioritize professional education, safe working conditions, fair employment practices, career development, and strategies that support the retention of qualified healthcare workers.

Workforce planning should include the full multidisciplinary team, recognizing the contributions of nurses, pharmacists, laboratory professionals, community health workers, technical personnel, and other professionals essential to healthcare delivery.

International professional mobility can provide important educational and employment opportunities, but recruitment practices should also consider their consequences for healthcare systems already experiencing workforce shortages. Collaborative training, professional exchanges, and support for local educational institutions can help promote mutual benefits.

Professional well-being should also be recognized as an institutional responsibility. Excessive workloads, inadequate staffing, unsafe environments, and limited opportunities for professional development can undermine both workforce retention and patient safety.

8. Promote responsible and equitable digital innovation

Digital technologies, telemedicine, and artificial intelligence offer important opportunities to improve healthcare access, clinical decision-making, education, and public health surveillance. However, their implementation should be guided by clearly identified needs rather than technological novelty alone.

Institutions should evaluate whether proposed digital interventions are accurate, safe, accessible, affordable, and appropriate for the healthcare environments in which they will be used.

Particular attention should be given to differences in technological infrastructure, digital literacy, language, and access to reliable internet connectivity. AI-based systems should be assessed for potential biases and differences in performance across patient populations.

Healthcare professionals must remain able to critically evaluate technological recommendations, and responsibility for clinical decisions should be clearly defined. Institutions should also establish procedures for data protection, incident reporting, performance monitoring, and the reassessment of technologies after implementation.

The success of digital innovation should ultimately be measured by its contribution to better healthcare rather than by its technical complexity.

9. Build international partnerships based on reciprocity and shared responsibility

Sustainable international cooperation requires relationships in which participating institutions contribute knowledge, experience, and resources while sharing responsibility for decisions and outcomes.

Partnership agreements should establish clear objectives, define institutional responsibilities, promote fair recognition of scientific contributions, and address issues concerning data ownership, authorship, resource allocation, and long-term sustainability.

Collaboration should avoid models in which better-resourced institutions determine priorities without meaningful participation from local partners. Instead, institutions should jointly identify healthcare challenges and develop solutions appropriate to the settings involved.

Trust develops through consistent behaviour, transparent communication, respect for commitments, and willingness to acknowledge difficulties. Partnerships should therefore include mechanisms for regular dialogue, shared evaluation, and the resolution of disagreements.

A successful international partnership is not defined solely by its geographical reach or the number of participating institutions, but by its ability to strengthen local capacities and generate benefits that can be sustained over time.

10. Translate scientific knowledge into measurable improvements in healthcare

The ultimate purpose of scientific education, research, and international cooperation is to improve health outcomes. Institutions should therefore establish clear connections between the knowledge they produce or share and the practical changes they seek to achieve.

Programmes should begin by identifying a specific healthcare problem, understanding its local causes, and selecting an evidence-informed intervention that can realistically be implemented.

Evaluation should consider both the implementation process and its consequences for healthcare delivery. Depending on the intervention, relevant indicators may include improvements in professional competencies, adherence to clinical practices, access to essential services, patient safety, or other locally defined outcomes.

Institutions should also assess whether benefits are distributed equitably and whether improvements can continue after the initial programme or external support has ended.

Unsuccessful interventions should not automatically be considered failures without value. When appropriately documented and analyzed, they can provide important information about organizational barriers, implementation difficulties, and the need for adaptation.

The translation of scientific knowledge into practice should therefore be understood as a continuous process of learning, evaluation, and improvement.

Together, these ten priorities provide a practical agenda for institutions seeking to contribute to global health. Their implementation will necessarily differ across healthcare systems, but the underlying principles remain consistent. Equitable access to knowledge, scientific integrity, effective prevention, resilient services, responsible innovation, and meaningful cooperation are interconnected elements of sustainable healthcare development.

For these commitments to produce lasting results, each institution should identify achievable objectives, assign responsibility for implementation, allocate appropriate resources, and review progress at regular intervals. Institutional success should be evaluated not only through the activities undertaken but also through the improvements achieved for healthcare professionals, patients, and communities.

A culture of continuous improvement

The long-term effectiveness of global health initiatives depends not only on their initial achievements but also on their ability to evolve, adapt, and remain useful over time. Healthcare challenges change as scientific evidence develops, populations evolve, technologies advance, and new environmental, social, and economic pressures emerge. Institutions and international partnerships must therefore develop a culture of continuous improvement that allows them to respond to changing needs while preserving their fundamental commitments to equity, scientific integrity, and patient safety.

Continuous improvement should be understood as an organized and ongoing process through which institutions evaluate their activities, identify limitations, learn from experience, and introduce appropriate changes. It requires more than periodic assessments or the publication of progress reports. Its value depends on whether information collected through monitoring and evaluation is translated into practical decisions that improve healthcare delivery.

An important component of this process is the preservation of institutional knowledge. International collaborations frequently depend on the commitment of individual professionals who establish relationships, coordinate activities, and promote shared projects. Although personal leadership is valuable, partnerships that rely exclusively on a small number of individuals may become vulnerable when responsibilities change, funding ends, or participants leave their institutions.

Sustainable cooperation therefore requires organizational structures capable of maintaining continuity beyond individual leaders or projects. Clear documentation of responsibilities, accessible educational resources, shared scientific materials, transparent reporting procedures, and agreed mechanisms for decision-making can help preserve knowledge and support the continuation of useful activities.

Mentorship is particularly important for developing this institutional continuity. Experienced professionals can support younger colleagues by sharing scientific knowledge, methodological expertise, and practical experience in healthcare organization and leadership. At the same time, younger professionals can contribute new perspectives, technological skills, and innovative approaches to emerging challenges.

Their involvement should extend beyond participation in educational activities. Students and early-career healthcare professionals should have opportunities to contribute to research design, quality improvement projects, programme evaluation, and institutional governance. Meaningful participation can strengthen professional development while ensuring that international collaborations remain open to new ideas and future leadership.

A culture of continuous improvement also requires institutions to create environments in which difficulties and unsuccessful interventions can be discussed openly. Healthcare programmes may fail to achieve their intended objectives because of inadequate resources, organizational barriers, unexpected clinical circumstances, or assumptions that do not reflect local realities.

Identifying these limitations should not be viewed exclusively as a negative outcome. When problems are examined systematically, they can provide valuable information for improving future interventions. Transparent reporting of both successful and unsuccessful experiences can support collective learning and help other institutions avoid repeating similar mistakes.

Regular evaluation should therefore be integrated into the ordinary activities of healthcare organizations and international partnerships. Institutions should review whether their objectives remain relevant, whether resources are being used effectively, and whether the intended beneficiaries are experiencing meaningful improvements.

Evaluation should also consider equity. An intervention may improve average performance while leaving some populations or healthcare facilities behind. Understanding who benefits, who encounters barriers, and whose needs remain unmet is essential for developing more inclusive approaches.

Scientific evidence should guide these assessments, but local experience and professional judgment are equally important for understanding implementation. Healthcare professionals working directly with patients often recognize practical difficulties that may not be apparent from aggregate indicators or formal institutional reports. Their participation in evaluation and decision-making can improve the relevance and feasibility of proposed changes.

International collaboration offers particular opportunities for shared learning because institutions operating in different settings may encounter similar challenges under different conditions. Comparing experiences can help identify which interventions are broadly applicable and which require substantial adaptation.

However, the purpose of such comparisons should not be to rank institutions according to resources or performance without considering their circumstances. Instead, international exchange should encourage the identification of effective practices, the understanding of contextual differences, and the development of solutions that can be adapted to local needs.

Digital educational resources, collaborative research networks, and shared quality improvement projects can support this process by facilitating communication and preserving knowledge across geographical boundaries. Their value is greatest when they allow participating institutions to contribute actively, question existing approaches, and apply lessons learned to their own healthcare environments.

Sustained improvement also requires institutional leadership that recognizes the importance of long-term investment. Educational programmes, infection prevention initiatives, workforce development, and healthcare quality improvement cannot depend exclusively on temporary enthusiasm or short funding cycles. They require stable responsibilities, appropriate resources, and mechanisms that allow effective activities to continue.

At the same time, continuity should not be confused with resistance to change. Institutions must remain willing to revise practices that are no longer supported by scientific evidence or that fail to produce meaningful benefits. Maintaining a successful learning culture requires balancing organizational stability with openness to innovation and critical reassessment.

Ultimately, a culture of continuous improvement transforms global health cooperation from a series of isolated activities into an enduring process of shared responsibility. Knowledge is continuously generated, evaluated, exchanged, and translated into practical action. Experience from different countries and healthcare settings contributes to a broader understanding of what works, under which conditions, and for whom.

The lasting value of international cooperation should therefore be measured by its ability to strengthen institutional capacity, support future generations of healthcare professionals, and produce sustainable improvements in patient care and population health. A resilient global health community is one that continues to learn, adapts to new challenges, and remains committed to improving healthcare through scientific evidence, equitable participation, and collective action.

14
Towards shared responsibility

From the language of solidarity to shared responsibility

The ambition of a borderless health community is neither to replace national health systems nor to claim that every challenge has a universal solution. It is to ensure that reliable knowledge, professional relationships and ethical commitments travel more freely than the disadvantages that currently constrain them. Local ownership and international connection are mutually reinforcing when partners share responsibility for goals and outcomes.

A borderless approach to global health provides an ethical and practical framework for international cooperation. It does not assume that professional differences or national responsibilities disappear. Instead, it treats these differences as opportunities for reciprocal learning. By exchanging knowledge openly, acknowledging resource limitations and building local capabilities, partners can generate benefits that no single institution could achieve alone. Cooperation strengthens accountability when each participant contributes within a shared commitment to health equity.

Climate change, infectious threats, workforce inequity, conflict and scientific misinformation will continue to test the institutions on which health depends. No educational platform can resolve these challenges alone. Yet education can build a common language; connection can make expertise available when needed; empowerment can strengthen local agency; and action can turn ideas into measurable improvements.

The next phase of global health will require sustained cooperation beyond statements of solidarity. It will depend on institutions capable of protecting scientific integrity, maintaining essential services, responding to infectious and climate-related threats, and distributing opportunities to learn and lead more fairly. Progress will be uneven, and some initiatives will need substantial revision. The value of international collaboration should be judged by its ability to recognize those differences, make evidence usable in diverse circumstances and remain accountable to the communities it serves.

The central principle of health beyond borders is that knowledge should lead to shared benefit. Scientific evidence becomes a public good when people can question it, adapt it, teach it and use it to protect others. A more resilient future will depend not only on discoveries, but also on

whether institutions can distribute their benefits fairly, strengthen local expertise and continue learning together across geographical and professional boundaries.

15
A united and independent scientific community

Unity of purpose without uniformity of thought

Global health challenges demand a scientific community capable of acting with cohesion while remaining intellectually independent. Infectious threats, antimicrobial resistance, climate-related disruption and widening inequities cannot be addressed effectively when scientific institutions operate as isolated competitors or when evidence is subordinated to political, commercial or ideological pressure. The community of science needs a shared commitment to reliable methods, professional ethics, transparent debate and the protection of human health [43].

Evidence is not a matter of personal preference or political affiliation. Scientific conclusions can be provisional, contested and revised, but uncertainty does not make carefully established findings interchangeable with unsupported claims. Good-faith disagreement identifies specific weaknesses in data or inference and proposes ways to test them. By contrast, selective distortion of results, manufactured doubt, intimidation of researchers and the promotion of claims disconnected from credible evidence do not constitute scientific pluralism. Defending science requires confronting such practices while preserving the freedom to investigate and criticize rigorously.

Scientific unity should never be mistaken for compulsory agreement. Progress depends on questioning established explanations, testing competing hypotheses, examining uncertainty and correcting conclusions when new findings emerge. Yet legitimate scientific dissent is not simply an alternative opinion, nor does it entitle every assertion to equal scientific standing. It is a reasoned challenge grounded in verifiable observations, transparent methods, coherent analysis and a willingness to submit claims to independent scrutiny. The strength of an argument must be judged by the quality and totality of the evidence, not by the prominence, conviction or influence of its proponents. A united scientific community defends these common rules of inquiry without demanding unanimity [2, 44].

Protecting scientific independence from undue interference

External pressures can arise from governments, political movements, funders, corporations, professional hierarchies, publishers or institutions seeking reputational advantage. They may influence which questions are investigated, whether inconvenient findings are communicated, how research is financed, or which experts are permitted to participate in public discussion. Scientific independence requires safeguards against undue interference throughout the research process, from agenda setting and study design to data interpretation, publication and public

communication [43, 44]. Independent scrutiny must remain possible even when findings are politically inconvenient, economically costly or unpopular. The legitimate evaluation of evidence cannot be replaced by pressure campaigns, commercial interests, ideological allegiance or orchestrated misinformation [43, 44].

Independence does not mean absence of accountability. Research must respect ethics, human rights, patient safety and legitimate democratic oversight. Funders and public authorities may establish lawful priorities and allocate resources, but they should not predetermine empirical findings, suppress well-founded criticism or demand that evidence be modified to support preferred conclusions. Decisions that incorporate social values or resource trade-offs should be identified as policy judgments rather than disguised as scientific certainties. Ethical oversight, including protection of research participants, is itself part of responsible science rather than an intrusion into scientific findings [45].

Scientific independence must also include independence from distorted publishing incentives. The scientific community should resist business practices that compromise editorial judgment, predatory publication schemes, the commercialization of authorship and evaluation systems driven primarily by journal rankings or article counts. Defending reliable journals and open science means supporting rigorous peer review, fair publication opportunities, transparent costs and timely correction of the literature, not protecting any publisher or institution from legitimate criticism. [46] [47]

Common standards and practical protections

Institutions can protect scientific freedom through transparent funding agreements, independent ethical review, disclosure and management of conflicts of interest, research protocols, accessible methods and appropriate data governance. Robust peer review, reproducibility, public correction of errors and procedures that allow researchers to raise concerns without retaliation are equally important. Professional societies and universities should defend these standards consistently, including when the results are inconvenient to their own members or partners. [48]

Cooperation across institutions can reduce vulnerability to pressure on any single research team. Joint statements grounded in evidence, independent methodological assessments, shared scientific resources and international professional solidarity can make it more difficult to isolate individuals who raise legitimate concerns. Such support must protect researchers from harassment without exempting their claims from scientific scrutiny.

Solidarity that includes every scientific community

A united global scientific community cannot be built around a small number of prestigious institutions. Researchers, clinicians, nurses, pharmacists, laboratory scientists, public health workers and community partners from different economic and geographical settings must be able to influence questions, contribute evidence, challenge assumptions and receive appropriate credit. Intellectual independence is weakened when participation depends on geography, institutional influence or financial capacity.

Equitable collaboration requires shared governance, fair authorship and access to education, research infrastructure and publication opportunities. It also requires respect for local expertise and the right of participating institutions to question proposals that do not fit their circumstances. Scientific solidarity becomes credible when it enables independent contributions rather than reproducing dependency.

Communication, public trust and collective responsibility

External interference is most effectively resisted by institutions that have earned public confidence through openness and competence. Scientists should communicate what is known, what remains uncertain and why recommendations may change. They should distinguish evidence from advocacy, disclose relevant interests and avoid presenting provisional findings as definitive. Reliable scientific communication does not require silence about disagreement; it requires the responsible explanation of disagreement. Public communication should neither create false equivalence between well-supported results and unsupported opinions nor dismiss credible methodological criticism as disloyalty.

The responsibility for defending scientific integrity extends to research institutions, professional associations, journals, educational organizations and individual scientists. None can guarantee independence alone. Together, they can strengthen the norms and institutional protections that allow science to inform public decisions without becoming an instrument of political or economic power.

A final commitment: one scientific community, shared values

The future of global health depends not only on the discovery of new knowledge but also on whether the institutions producing and applying it remain trustworthy, open and free to follow the evidence. A common scientific purpose should bridge professional, disciplinary and national differences while respecting legitimate pluralism and local autonomy.

To stand united against undue external interference is to defend the freedom to investigate, the obligation to disclose uncertainty, the responsibility to correct mistakes and the right of every

community to participate in the benefits of science. This is not a demand for unanimity; it is a commitment to the conditions that make honest disagreement, rigorous investigation and collective progress possible.

Health Beyond Borders ultimately calls for a scientific community united in integrity, independent in judgment, inclusive in participation and unwavering in its commitment to human well-being. Knowledge must remain open to challenge, institutions accountable to the public, and international solidarity strong enough to protect the scientific principles on which resilient and equitable health systems depend.

Key messages

- Scientific unity rests on shared methods, intellectual integrity and commitment to the public good—not enforced agreement.
- Protect justified scientific dissent grounded in verifiable evidence while rejecting misinformation and manufactured doubt.
- Resist inappropriate political, economic and institutional pressure through transparent governance and independent review.
- Defend equitable participation and scientific freedom globally, while remaining accountable to ethical and methodological standards.
- Confront the crisis of scientific publishing through transparent editorial standards, credible peer review, action against paper mills and predatory practices, fair access to knowledge, and research assessment based on quality rather than quantity.

16
Ten Years of the Global Alliance for Infections in Surgery: Knowledge Shared with Respect

Founded in 2016, the Global Alliance for Infections in Surgery (GAIS) marks its tenth anniversary in 2026. It grew from the conviction that surgical infections, antimicrobial resistance and patient safety cannot be addressed effectively by a single discipline or country. From its earliest international collaborations, the Alliance brought together clinicians and researchers working in contrasting health systems to develop shared, scientifically grounded approaches that could be adapted locally [49, 50].

From an international initiative to a community of shared expertise

The 2016 AGORA initiative provided an early scientific foundation by examining rational antimicrobial use in intra-abdominal infections with an international, multidisciplinary perspective [49]. Subsequent work on antimicrobial stewardship and a global declaration concerning appropriate antimicrobials along the surgical pathway broadened this approach beyond the operating theatre to encompass prevention, prophylaxis, treatment, organizational responsibility and continuous assessment [50, 51]. These efforts also showed that differences in access to medicines, microbiology services and clinical resources must be considered rather than hidden behind a supposedly universal model [52].

An important part of this work has been the exchange of expertise among surgeons, infectious disease physicians, microbiologists, pharmacists, intensivists, epidemiologists, infection prevention specialists and nurses. Different disciplines identify different problems along the patient pathway. A microbiologist may clarify diagnostic uncertainty; a pharmacist may improve dosing and antimicrobial review; a nurse may identify practical failures in infection prevention; and a surgeon or intensivist may explain the constraints affecting timely source control. Scientific progress becomes more useful when these perspectives are considered together rather than placed in competition.

Respect is the foundation of meaningful global collaboration

For the Alliance, the value of an international network should not be measured only by the number of countries represented or papers published. Its credibility depends on the quality of the relationships it sustains. Every professional, regardless of nationality, institutional prestige,

economic resources, language, seniority or professional title, deserves to be listened to with respect. Respect means allowing others to explain their clinical realities, recognizing their intellectual contributions, acknowledging uncertainty and accepting constructive disagreement. It also means ensuring that people who generate knowledge in resource-limited settings are not treated merely as data providers or local implementers.

The exchange must work in both directions. Professionals working in well-resourced systems may contribute specialized technology, laboratory infrastructure and methodological expertise. Colleagues working under severe constraints often develop practical skills in prioritization, adaptation, continuity of care and the use of limited resources. Neither form of experience should be idealized or dismissed. Both can identify solutions that may be overlooked elsewhere. Equal dignity does not mean that every suggestion has equivalent evidentiary support; it means that every contribution deserves fair consideration through transparent and respectful scientific methods.

Respect also has practical implications for research and education. Partners should agree on aims, responsibilities, authorship, access to data and dissemination of results. Educational materials should be accessible where possible, sensitive to local circumstances and open to revision when implementation reveals limitations. Disagreement should be addressed through evidence and dialogue, without personal attacks or institutional hierarchies silencing participants. A collaborative network is strengthened when junior colleagues, professionals in smaller hospitals and experts from underserved regions can participate meaningfully in scientific decisions.

From shared publications to better care

The scientific contributions developed with GAIS and partner societies illustrate the evolution from broad principles to practical guidance. International clinical pathways for intra-abdominal infections and skin and soft-tissue infections [53, 54] linked diagnosis, timely source control, appropriate treatment and multidisciplinary decision-making. A worldwide survey addressed the need for an organizational model covering the entire surgical pathway [55]. Later publications examined persistent uncertainties in surgical antibiotic prophylaxis [56], proposed an evidence-based prophylaxis bundle [59], and developed collaborative recommendations for antibiotic prophylaxis in trauma [60]. The 2023 declaration on infection prevention and management in global surgery emphasized that effective infection care requires prevention, clinical expertise and fair access to resources [58].

The WARNING call to action: ten golden rules

A particularly significant milestone was the 2023 WARNING position statement, “Ten golden rules for optimal antibiotic use in hospital settings.” Developed by an international task force of 295

specialists from 115 countries, the paper translated the need for antimicrobial stewardship into ten actionable principles for hospital practice [57]. It brought together scientific and professional perspectives from surgery, infectious diseases, pharmacy, intensive care, microbiology, infection prevention and public health. The emphasis is not only on choosing an antibiotic but on making a justified decision about whether treatment is needed, selecting appropriate treatment, reviewing it as new information becomes available, controlling the source of infection, preventing healthcare-associated infections and monitoring prescribing practices. Its international scope is an example of collective scientific authorship serving a shared health priority.

Position statements and consensus papers across the surgical pathway

The Alliance has also contributed to evidence-informed position statements aimed at difficult bedside decisions. The 2024 “Intra-abdominal infections survival guide” addressed recognition and treatment of these potentially life-threatening infections [61]. A 2024 paper connected infection prevention and control with the basic objectives of antimicrobial stewardship [62]. The 2026 position statement on necrotizing soft-tissue infections highlighted early recognition, prompt surgical debridement, targeted antimicrobial treatment, haemodynamic support and multidisciplinary coordination [63]. Read together with the global pathways and prophylaxis papers, these contributions form a coherent scientific continuum: prevent avoidable infections, recognize severe disease early, provide effective source control, prescribe antibiotics responsibly and evaluate outcomes [53, 54, 59–62, 64].

Scientific dialogue, global webinars and open education

Throughout its first decade, the Global Alliance for Infections in Surgery has complemented scientific publications with international educational initiatives, including the 2021 Masterclass on infections in surgery, the 2022 Global Webinar involving over 100 speakers, and the 2023 and 2024 webinars focusing on antimicrobial resistance, One Health, infection prevention and antimicrobial stewardship. A further educational milestone was the free, three-volume digital textbook Global Infection Prevention and Management in Healthcare, first published on 18 November 2024 (ISBN 978-88-943799-3-8) [64]. Its volumes cover (1) antimicrobial resistance and One Health, (2) infection prevention and control and antimicrobial stewardship, and (3) sepsis and infections in surgery. The textbook complements the Alliance’s position statements and webinars by offering an accessible, multidisciplinary resource that can be consulted repeatedly and adapted to professional education.

From research outputs to meaningful implementation

Scientific production and webinar participation are important, but their ultimate value depends on what changes in patient care. Adapting these resources requires local ownership, teams capable of monitoring prescribing and infection outcomes, microbiological support, and continued feedback. The Alliance's work is especially relevant when it stimulates professionals to compare experiences without requiring every setting to follow an identical operational model. International evidence must guide practice while remaining sensitive to feasibility, health-system inequities and the experiences of clinicians working with limited resources [52, 55, 57, 58].

However, publication is not the final objective. The true test is whether shared knowledge produces safer practices, stronger local teams and more equitable access to effective care. This requires implementation plans, available resources, local leadership, surveillance, feedback and willingness to learn when an intervention does not work as intended. Global networks can connect people and evidence; the lasting improvement must be achieved and owned by healthcare professionals and institutions in their own settings.

Health Without Borders Academy Hub: from shared experience to collective action

The tenth anniversary of the Global Alliance for Infections in Surgery (GAIS) offers an opportunity to extend the principles of international scientific collaboration beyond surgical infections and towards the broader challenges of global health. This evolution is reflected in the development of the Alliance's Global Health Section and the Health Without Borders Academy Hub, conceived as an open, multidisciplinary educational and collaborative platform connecting healthcare professionals, researchers, students, educators, institutions and communities across geographical, cultural and professional boundaries.

An important scientific foundation for this broader vision was provided by the international declaration *Global health at crossroads: uniting together to overcome challenges, restore trust and advance priorities for a sustainable future*, published in the *World Journal of Emergency Surgery* in November 2025 [45]. Developed through the contribution of 366 healthcare professionals and scientists from 119 countries across six continents, the article represents a collective appeal to protect scientific integrity, rebuild public trust and strengthen international solidarity in response to the increasingly interconnected challenges affecting global health.

The declaration emphasizes that contemporary health threats cannot be considered independently. Emerging and re-emerging infectious diseases, antimicrobial resistance, climate change, armed conflicts, humanitarian emergencies, persistent health inequalities and the weakening of international cooperation interact with one another, increasing the vulnerability of populations and healthcare systems. At the same time, misinformation, political interference in

scientific decision-making, declining research integrity and instability in international health financing threaten the credibility and effectiveness of public health institutions. The article argues that addressing these challenges requires more than technological advances or isolated national strategies. It demands transparent governance, evidence-based policies, ethical leadership, resilient healthcare systems and sustained cooperation across disciplines and countries [45].

A particularly important message of the declaration concerns the need to restore trust in science. Scientific credibility cannot be maintained through authority alone; it must be earned through intellectual honesty, transparency, recognition of mistakes, willingness to revise decisions when new evidence emerges and effective communication with the public. Science should remain independent of political and ideological interference while also accepting responsibility for its limitations and uncertainties. Respectful dialogue, academic freedom and the ability to disagree constructively are essential conditions for meaningful scientific progress.

The declaration also calls attention to the importance of health equity and the unequal distribution of scientific resources, professional opportunities and access to essential healthcare. International collaboration should not reproduce relationships in which knowledge and decisions flow exclusively from wealthier institutions towards countries with fewer resources. Professionals working in resource-constrained settings possess valuable experience in prioritization, adaptation, efficient resource utilization and the implementation of essential interventions under difficult conditions. Their knowledge can contribute substantially to improving healthcare delivery worldwide. Genuine solidarity therefore requires reciprocal learning, fair recognition of contributions and opportunities for shared leadership.

These principles provide a meaningful conceptual framework for the Health Without Borders Academy Hub. While the 2025 declaration identifies the ethical, scientific and institutional responsibilities facing the international health community, the Academy Hub aims to translate comparable principles into sustained educational exchange, professional relationships and collaborative initiatives. Its ambition is to help bridge the distance between scientific knowledge and practical implementation, recognizing that evidence becomes valuable to populations only when it can be understood, adapted and applied in real healthcare environments.

The Hub brings this ambition together through four complementary commitments: Educate, Connect, Empower and Act.

Educate means promoting access to reliable scientific information, critical appraisal, evidence-based practice and multidisciplinary learning. Education should remain accessible to professionals working in different economic and institutional circumstances, avoiding unnecessary barriers related to geography, language or financial resources. It should also encourage a critical

understanding of scientific uncertainty, emerging evidence and the responsibilities associated with communicating health information.

Connect means building durable relationships among professionals, disciplines, generations and countries. International networks should encourage genuine two-way exchanges in which knowledge circulates in multiple directions. Collaboration is strengthened when individuals can share experiences, question assumptions and learn from different healthcare environments without professional hierarchy becoming an obstacle to participation. Mutual respect, rather than institutional prestige or geographical origin, should remain the foundation of these relationships.

Empower means enabling participants to develop professional confidence, scientific independence and leadership capacity. Particular attention should be given to younger healthcare professionals and colleagues working in settings with limited resources, who may face structural barriers to scientific participation despite possessing valuable knowledge and experience. Mentorship, collaborative authorship, equitable opportunities and locally led educational initiatives can contribute to strengthening sustainable professional capabilities.

Act means moving beyond education and discussion towards feasible interventions, shared projects and measurable improvements in healthcare. Educational activities should be connected, whenever possible, to implementation strategies, evaluation and feedback. A programme addressing infection prevention, for example, should not be judged solely by the number of participants attending a webinar, but also by its capacity to support locally appropriate practices, strengthen professional collaboration and improve patient safety. Similarly, initiatives addressing antimicrobial resistance, preparedness or health inequities should encourage practical approaches adapted to available resources.

The relationship between education and implementation is particularly important. Knowledge alone does not automatically change professional behaviour or improve health outcomes. Implementation requires leadership, organizational commitment, appropriate resources, multidisciplinary cooperation and an understanding of the barriers encountered in different settings. The Academy Hub can provide a collaborative environment in which participants learn not only what scientific evidence recommends, but also how interventions may be adapted, introduced, evaluated and sustained.

The broader perspective advocated in the 2025 declaration also reinforces the importance of the One Health approach, recognizing the close connections between human, animal and environmental health. Antimicrobial resistance, zoonotic diseases, environmental degradation and climate-related health threats cannot be addressed effectively within the boundaries of a single discipline. The Academy Hub therefore offers an opportunity to encourage dialogue among

clinical medicine, public health, microbiology, epidemiology, environmental sciences, veterinary medicine, health policy and other relevant fields.

This multidisciplinary ambition must remain grounded in mutual respect. International scientific communities are strengthened when they recognize both formal academic achievements and the practical experience accumulated by professionals delivering essential care under challenging circumstances. Listening is as important as teaching. Understanding why an intervention succeeds in one healthcare system but encounters difficulties in another can generate knowledge of value to all participants. Scientific rigor and equitable participation are not competing objectives; each can strengthen the other.

The Health Without Borders Academy Hub should therefore be understood not as a replacement for the Alliance's established work on surgical infections, but as a complementary extension of the collaborative principles developed during its first decade. Its long-term value will depend on the ability to sustain educational exchange, encourage equitable partnerships, strengthen local capabilities and support initiatives whose outcomes can be assessed openly.

The international declaration published in 2025 reminds us that global health is not simply a matter of scientific progress, technological innovation or financial investment. It is also a question of trust, responsibility, solidarity and the willingness to work together across differences [45]. The Health Without Borders Academy Hub seeks to contribute to this vision by connecting knowledge with people, education with implementation and scientific collaboration with collective action.

Finally, the most meaningful legacy of ten years of international cooperation should not be measured only by the number of publications, educational events or participating countries, but by the relationships established, the knowledge shared, the capacities strengthened and the benefits reaching patients and communities. In an increasingly interconnected world, health cannot be protected within isolated national or professional boundaries. Scientific knowledge becomes more powerful when it is shared with humility, developed through mutual respect and transformed into collective action for the benefit of all.

A decade of relationships and a responsibility for the future

The tenth anniversary is therefore an occasion for gratitude to the colleagues around the world who have contributed their time, experience, critical judgment and trust. Many meaningful relationships have developed through dialogue across borders, scientific collaboration and a common commitment to patients. Their value extends beyond individual projects. They demonstrate that scientific cooperation can be sustained by personal integrity, mutual recognition and a willingness to help one another learn.

Looking ahead, the Alliance should continue to foster participation across countries and professions, protect independent scientific discussion, support younger professionals and translate global evidence into feasible local action. The future of the network will depend not simply on expanding its reach but on maintaining the principles that make cooperation worthwhile: openness, humility, fairness, transparency and respect for everyone. The most enduring achievement of ten years of collaboration is not any single publication. It is the experience of building a community in which differences in geography, culture, discipline and resources become opportunities for reciprocal learning and a shared responsibility to improve care.

Key messages

- Ten years of GAIS show that sustained international networks can connect expertise across disciplines, countries and healthcare settings.
- Mutual respect, recognition of contributions and freedom to disagree are prerequisites for equitable scientific collaboration.
- Resource-limited and resource-rich health systems can learn from one another; scientific rigor and local adaptation must advance together.
- The value of shared knowledge is ultimately measured by implementation, stronger local capacity and improved patient care.
- The Health Without Borders Academy Hub extends this commitment through Educate, Connect, Empower and Act, linking equitable learning to locally meaningful action.

17

Building BRIDGES: From Shared Principles to Collective Action

The challenges facing global health are complex, interconnected, and increasingly difficult to address through isolated initiatives. Infectious diseases, antimicrobial resistance, climate change, humanitarian crises, inequalities in healthcare access, and threats to scientific independence demonstrate that no country, institution, or professional community can act effectively alone. These challenges require more than scientific progress. They demand a shared vision grounded in knowledge, responsibility, cooperation, and the capacity to translate principles into measurable improvements.

Throughout this book, a central conviction has emerged: global health is not simply about crossing geographical borders, but about overcoming the barriers that prevent knowledge, opportunities, and healthcare from being shared equitably.

These barriers may be economic, political, institutional, cultural, technological, or scientific. Some limit access to essential care; others restrict education, research participation, scientific publication, or the implementation of effective interventions. Overcoming them requires building lasting connections between people, institutions, disciplines, and countries.

The essential principles of this approach can be summarized in one word: BRIDGES.

Seven principles for a shared global health future (figure 8)

B – Beyond Borders

Health challenges transcend geographical boundaries, and effective responses must do the same. International cooperation should become a continuous responsibility rather than an exceptional response to emergencies. Moving beyond borders does not mean disregarding national responsibilities or local priorities, but recognizing that health systems become stronger through sustained cooperation, mutual understanding, and shared scientific knowledge.

R – Reciprocal Learning

Every country and healthcare system has something to teach and something to learn. Scientific progress should not be understood as a one-directional transfer of knowledge from wealthier institutions to those with fewer resources. Resource-constrained settings frequently develop valuable approaches to prioritization, adaptability, efficient organization, and sustainable healthcare

delivery. Recognizing these contributions creates more equitable partnerships and allows innovation to emerge from diverse experiences.

I – Independent Science

Scientific independence is an essential condition for public trust and responsible decision-making. Research and scientific communication must remain protected from undue political, ideological, institutional, and commercial interference. At the same time, defending science requires preserving legitimate disagreement based on rigorous methods and verifiable evidence. Scientific unity must never imply uniformity of thought. Evidence is not opinion, and protecting open scientific debate does not mean granting unsupported claims the same credibility as established scientific findings.

D – Diversity and Equity

Diversity in geography, experience, professional background, and available resources enriches scientific understanding. Equity requires more than equal declarations of opportunity: it demands practical measures that allow underrepresented communities and institutions to participate in education, research, governance, and decision-making. A truly global scientific community must recognize different forms of expertise and ensure that the benefits of scientific progress reach populations that have historically remained underserved.

G – Global Solidarity

Solidarity must evolve from an ethical aspiration into a sustained commitment. Meaningful international partnerships depend on mutual respect, shared responsibilities, transparent governance, and fair recognition of contributions. Their success should not be measured primarily by institutional visibility, the number of participating countries, or the volume of scientific activities, but by their capacity to strengthen local expertise, improve healthcare systems, and create durable relationships.

E – Education for Action

Education is a fundamental instrument for reducing inequalities and strengthening healthcare capacity, but knowledge alone cannot guarantee change. Scientific evidence must be translated into practical interventions adapted to local needs, organizational conditions, and available resources. Effective implementation requires leadership, institutional support, appropriate infrastructure, multidisciplinary participation, continuous evaluation, and the willingness to revise strategies when results are insufficient. The true value of education lies not only in what professionals learn, but in what they are subsequently able to improve.

S – Sustainable Impact

The ultimate objective of global health cooperation is to generate improvements that endure. Sustainable impact requires strengthening local institutions, protecting the healthcare workforce,

using resources responsibly, reducing environmental harm, and developing systems capable of adapting to future challenges. Progress must be evaluated through meaningful outcomes, including improved access, safer care, stronger professional competencies, reduced inequalities, and greater resilience. Initiatives should be designed not merely to produce immediate results, but to leave lasting capabilities within the communities they serve.

From principles to responsibility

BRIDGES is more than an acronym. It represents a way of understanding the relationship between science and society.

It reminds us that generating knowledge is not enough if access to that knowledge remains unequal; that educating professionals is insufficient if healthcare organizations cannot implement what has been learned; that international collaboration loses its meaning when decision-making and recognition remain concentrated in a few institutions; and that scientific progress cannot fully serve humanity unless its independence, integrity, and credibility are protected.

It also emphasizes that the scientific community must remain united around common principles while preserving its essential capacity for critical discussion. Unity should be built on shared standards of evidence, intellectual honesty, transparency, and respect for rigorous disagreement, rather than on unquestioning acceptance of prevailing views.

The experience of recent global crises, particularly the COVID-19 pandemic, has demonstrated the consequences of fragmented responses, unequal access to essential resources, and insufficient preparedness. Yet these experiences have also revealed the extraordinary potential of international scientific collaboration when knowledge, expertise, and responsibilities are shared.

The next challenge is to transform these lessons into permanent institutional capabilities. This requires moving from occasional cooperation to sustainable partnerships, from educational activities to practical implementation, from declarations of equity to meaningful participation, and from scientific productivity to demonstrable improvements in human health.

Building bridges is therefore a collective responsibility. Governments, universities, scientific societies, healthcare institutions, professional networks, researchers, and communities all have a role to play. No single institution can accomplish this transformation independently, but every institution can contribute by making scientific knowledge more accessible, protecting professional integrity, supporting equitable collaboration, and translating evidence into practical action.

Above all, building bridges requires recognizing that the future of global health depends not only on technological innovation or financial investment, but also on the values that guide their use. Scientific excellence without equity risks widening existing inequalities. Solidarity without

implementation risks remaining symbolic. Education without opportunities for application may fail to improve care. Innovation without accountability may create new forms of exclusion. These dimensions must advance together.

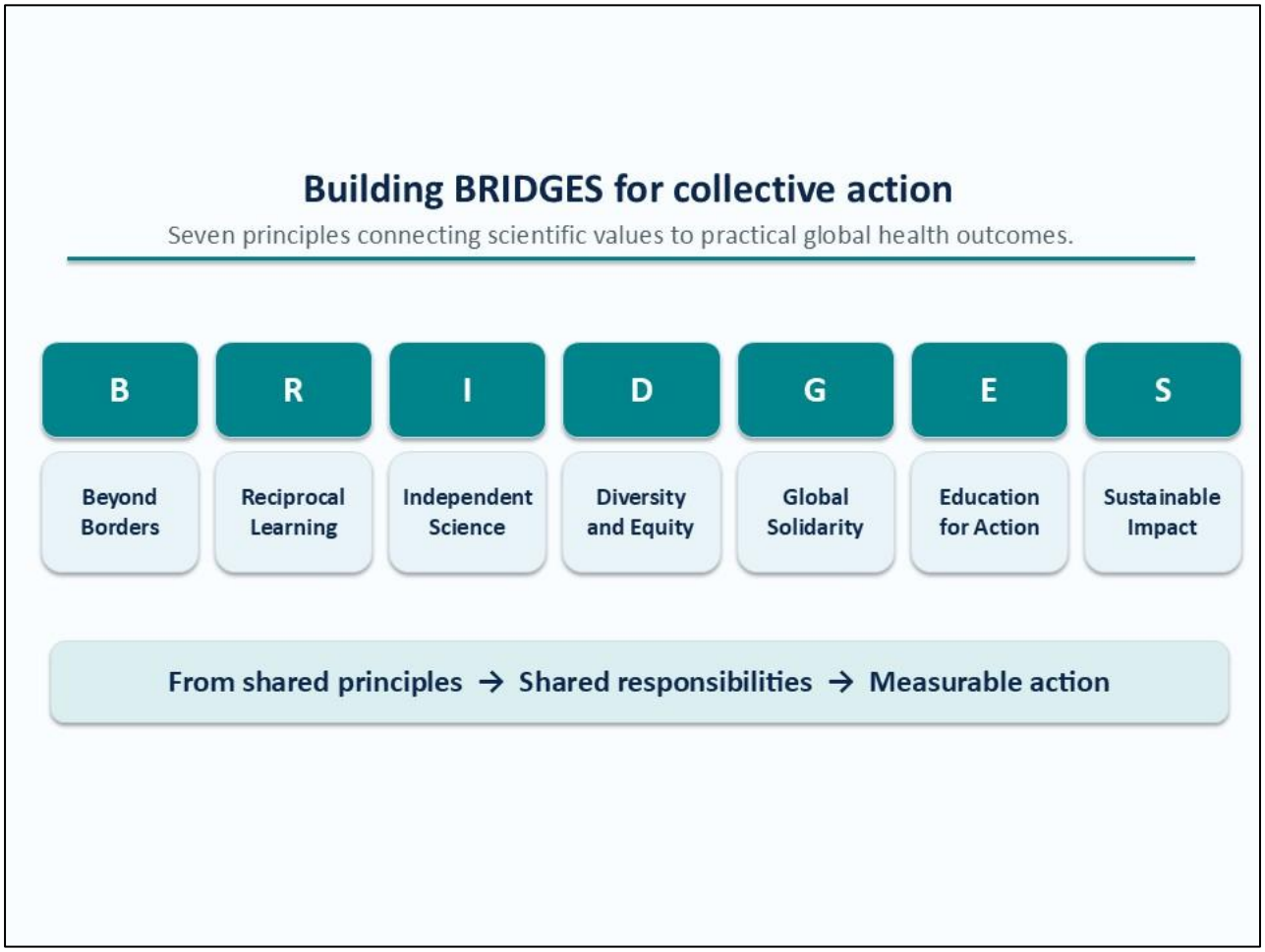


Figure 8. Seven principles for a shared global health future

A final message

The reflections in this book should therefore be read as an invitation to rethink health, rather than as a comprehensive treatment of Global Health. Respect for specialists and established evidence is fully compatible with an open, interdisciplinary discussion of what health should mean for individuals, communities and institutions today.

The future of global health will not be determined solely by how much knowledge humanity produces, how many technologies it develops, or how many international initiatives it launches. It will also depend on how fairly knowledge is shared, how independently science is protected, how effectively evidence is implemented, and how responsibly institutions collaborate.

The greatest achievement of global health should not be the accumulation of scientific knowledge within a limited number of institutions, but the development of a worldwide community capable of using that knowledge to protect and improve human life.

This is the responsibility of the present generation and the opportunity of those who will follow.

Science provides the evidence.

Education shares the knowledge.

Equity creates opportunity.

Solidarity builds the bridges.

Implementation transforms knowledge into action.

And collective responsibility makes progress sustainable.

Ultimately, global health is not only about the challenges we face together, but about the future we choose to build together.

The future of global health is not about removing every border, but about building bridges that no border can divide.

About the Author

Massimo Sartelli is an Italian general and emergency surgeon with extensive clinical, scientific, and international experience in surgical infections, sepsis, infection prevention and control, and antimicrobial resistance. He is President of the Italian Multidisciplinary Society for Infection Prevention and Control in Healthcare Organizations (SIMPIOS) and Founder and Director of the Global Alliance for Infections in Surgery (GAIS).

During the COVID-19 emergency, Massimo Sartelli was awarded the title of Knight of the Order of Merit of the Italian Republic in December 2020, in recognition of his significant contribution to the management of the pandemic. This prestigious honour acknowledged his professional dedication and commitment to public service during an unprecedented global health crisis, a period in which clinical responsibility, institutional engagement, and solidarity assumed particular significance.

Throughout his professional career, he has combined frontline clinical practice with scientific research, international collaboration, and educational activities. His involvement in international clinical guidelines, multicenter research projects, scientific publications, and global educational initiatives has brought him into contact with healthcare professionals working in diverse geographical, cultural, and socioeconomic settings.

These experiences have progressively shaped his understanding of health as a global responsibility that extends far beyond hospitals, individual diseases, and national borders. Working with colleagues from different healthcare systems has reinforced his awareness that scientific progress does not automatically translate into better health outcomes. Access to reliable knowledge, adequate resources, professional education, and effective healthcare services remains profoundly unequal across the world.

Over the years, he has become increasingly convinced that the major challenges facing global health cannot be addressed through clinical expertise, scientific discoveries, or technological innovation alone. They require equitable access to education, international solidarity, multidisciplinary cooperation, environmental responsibility, and strong, independent scientific institutions capable of translating evidence into meaningful action.

His commitment to international scientific networks reflects a fundamental belief: knowledge should not remain confined within institutions, countries, or professional communities, but should be shared as widely and equitably as possible. Scientific collaboration is not simply an opportunity to exchange information; it is a means of reducing inequalities, strengthening healthcare systems, and building relationships based on mutual respect and shared responsibility.

At the same time, his professional experience has reinforced his conviction that science must remain independent of political, ideological, and commercial interference. Scientific progress depends on intellectual freedom, methodological rigor, transparency, and the protection of legitimate, evidence-based dissent. Defending science does not mean rejecting criticism or demanding unanimity, but preserving the principles that distinguish verifiable evidence from personal opinion and unsupported claims.

Rethinking Health Beyond Borders emerges from this combination of clinical experience, scientific engagement, international dialogue, and personal reflection. Moving beyond the traditional boundaries of clinical medicine, the manual explores the interconnected relationships between human health, environmental sustainability, education, social inequalities, scientific integrity, and collective responsibility.

The book is not intended merely as a review of scientific knowledge or a collection of recommendations. It also represents an invitation to reflect on the role of science in contemporary society, the ethical responsibilities of healthcare professionals, and the importance of building a more inclusive and cooperative global scientific community.

Through this publication, Massimo Sartelli seeks to share both scientific knowledge and personal perspectives developed over years of professional experience and collaboration with colleagues around the world. He recognizes that some of these reflections may invite different interpretations or legitimate disagreement, which he considers an essential component of open and constructive scientific dialogue.

At the heart of this book lies the simple conviction that science becomes more valuable when knowledge is shared, more credible when it remains independent, and more effective when people and institutions work together beyond geographical, professional, and cultural boundaries.

Rethinking Health Beyond Borders is ultimately an expression of this vision: a call for a global scientific community that is open to dialogue, united in the defense of evidence, committed to equity, and guided by the shared responsibility to protect human health and the future of our planet.

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