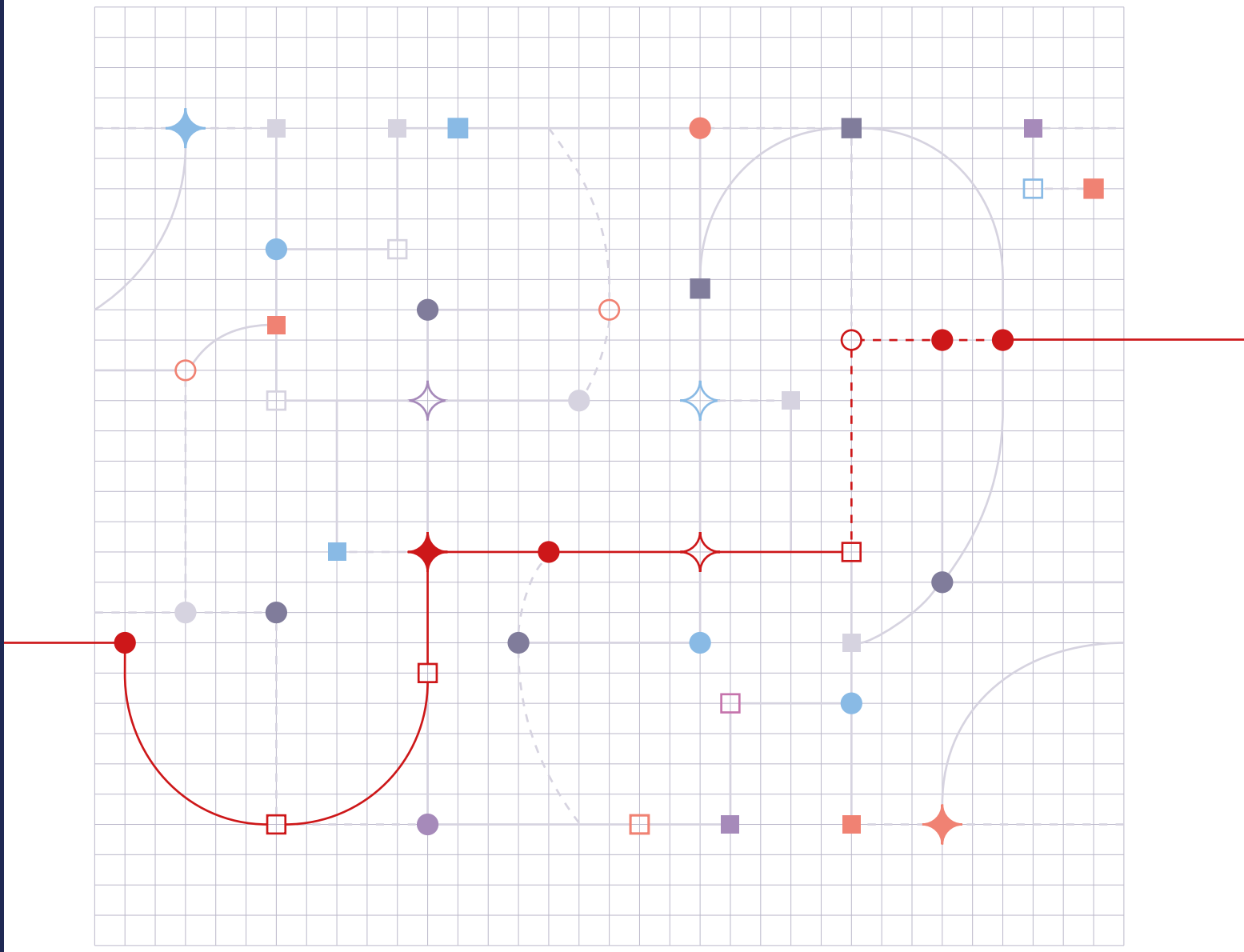
Blueprint for strengthening responses to fungal disease and antifungal resistance

Implementation guidance



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Abbreviations

AMS	antimicrobial stewardship
AFR	antifungal resistance
AFS	antifungal stewardship
AFST	antifungal susceptibility testing
AMR	antimicrobial resistance
FPPL	fungal priority pathogens list
IPC	infection prevention and control
LMICs	low- and middle-income countries
NTD	neglected tropical diseases
R&D	research and development
TB	tuberculosis
UHC	Universal Health Coverage
WHO	World Health Organization

Executive summary

Fungal disease, and the growing threat of antifungal resistance, represent one of global health's most underestimated threats. Affecting more than 300 million people and causing millions of deaths each year, these infections also inflict chronic illness, disability and loss of productivity. Nevertheless, they remain largely invisible within global priorities despite their profound human and economic toll. The rise of antifungal resistance is further eroding already limited treatment options, prolonging illness and increasing mortality globally, driven in large part by the widespread agricultural and environmental use of antifungals that select for cross-resistance in human pathogens.

In 2022, the first *World Health Organization (WHO) fungal priority pathogens list to guide research, development and public health action* was published, and was the first global effort to identify fungal pathogens of greatest public health concern. This landmark initiative brought long-overdue visibility but also exposed a critical gap between recognition and action. To close this gap, and in response to Member States and partners' requests for guidance, the WHO developed this blueprint to strengthen responses to fungal disease and antifungal resistance.

Aligned with the *Global action plan on antimicrobial resistance* and the universal health coverage agenda, this guidance operationalizes global priorities through feasible, context-adaptable actions. It complements and strengthens existing health programmes (e.g. antimicrobial resistance, human immunodeficiency virus, tuberculosis, neglected tropical diseases, and water and sanitation), to strengthen preparedness, expand access and reduce preventable deaths due to fungal disease, while contributing to efforts to mitigate antifungal resistance.

Rooted in the principles of equity, One Health, efficiency and systems strengthening, the guidance is organized around four interlinked domains, which together provide a framework for implementation:

- **Domain 1: Public health and health system interventions** focuses on strengthening awareness, preparedness and response to fungal disease and antifungal resistance, by embedding antifungal stewardship within antimicrobial resistance (AMR) programmes and advancing education, workforce training, and infection prevention and control guidance to strengthen responses to fungal disease and antifungal resistance.
- **Domain 2: Therapies, technologies and innovation systems** focuses on expanding equitable access to quality-assured antifungal medicines and diagnostics while stimulating research, innovation and market incentives through coordinated regulatory and financing mechanisms.
- **Domain 3: Laboratory systems, surveillance and outbreak preparedness** focuses on building resilient laboratory networks and integrated surveillance systems for fungal disease and antifungal resistance to enhance diagnostics, detection, data quality and evidence-informed policy.
- **Domain 4: Social, environmental and One Health drivers** focuses on addressing the social, agricultural and environmental determinants of fungal disease and antifungal resistance through One Health and climate-resilient approaches that reduce risk and strengthen long-term resilience.

This implementation guidance provides a structured blueprint grounded in prioritization and feasibility to support national and regional responses. It enables countries to translate priorities into coordinated action, strengthen access to prevention, diagnosis and treatment, and advance more effective and sustainable responses to fungal disease and antifungal resistance.

1 Introduction

Fungal disease and antifungal resistance (AFR) remain among the most underestimated threats to global health. They affect hundreds of millions of people each year yet remain under-recognized, underdiagnosed, poorly managed and under-resourced *(1,2)*. The true burden is likely to be far higher than current estimates, however, reflecting poor data quality, limited surveillance, and constrained diagnostic capacity, particularly in low-resource settings where reliance on empirical therapy continues to fuel resistance *(3,4)*.

Superficial fungal diseases account for most cases and drive chronic morbidity and economic loss. However, invasive fungal infections – including aspergillosis, candidiasis, cryptococcosis, mucormycosis, pneumocystosis and disseminated histoplasmosis – carry unacceptably high case-fatality rates, even with advanced care *(5–9)*. In many low- and middle-income countries (LMICs), limited awareness, access to diagnostic tests and treatments means these infections are often missed, detected late or remain untreated *(10)*. Although most fungi are not directly transmitted between people, several clinically important species, such as *Pneumocystis jirovecii* and *Trichophyton indotineae*, can spread within communities and health care settings, reinforcing the need to integrate fungal infection prevention and control (IPC) into broader antimicrobial resistance (AMR) strategies.

Even when non-fatal, fungal diseases cause chronic, debilitating illness and lasting social and economic consequences. Conditions such as chronic pulmonary aspergillosis and other chronic respiratory fungal diseases, chromoblastomycosis, fungal mycetoma, and multidrug-resistant dermatophytosis can lead to permanent lung damage, disfigurement, disability, and stigma, particularly among marginalized populations *(11)*. The burden falls disproportionately on people living with human immunodeficiency virus (HIV), cancer patients, transplant recipients, those on immunosuppressive therapy, and individuals with chronic lung disease or trauma, all of which may be challenges that are further compounded in LMICs *(12,13)*. Even among immunocompetent individuals, where fungal disease was once considered uncommon or mild, outcomes can be severe due to diagnostic delays, limited access to antifungal medicines, AFR, and the increasing use of therapies that suppress or modulate the immune system.

AFR limits treatment options, complicates management, and is associated with high mortality, particularly in health care-associated outbreaks. Some fungi are intrinsically resistant to existing treatments, such as those causing eumycetoma, while others – including *Candidozyma auris (Candida auris), Trichophyton indotineae, Nakaseomyces glabratus (Candida glabrata), Candida parapsilosis* and azole-resistant *Aspergillus fumigatus* – have acquired resistance, underscoring the scale and urgency of this threat *(6,14,15)*. Resistance is further amplified by antifungal use across clinical, agricultural and industrial settings, including “dual-use” compounds that select for cross-resistance to medical agents, exacerbating the challenges of a limited drug pipeline, scarce susceptibility testing, and delayed diagnosis *(16,17)*. These pressures make fungal infections increasingly difficult to manage and highlight persistent gaps in antifungal stewardship (AFS) *(18)*.

Fungi are ubiquitous across human, animal and environmental systems, making their control inherently a One Health challenge. Similarly, resistance and disease emergence are sustained through intersecting pathways that link clinical, agricultural and ecological domains. Emerging threats, such as zoonotic sporotrichosis in parts of South America, illustrate these connections and expose major gaps in integrating fungal infections and AFR into health system planning, surveillance and cross-sectoral coordination *(19)*. Social and structural determinants, including poverty, overcrowding, inadequate housing and occupational exposure, further heighten vulnerability and expand the reach of pathogenic fungi *(20,21)*. Climate change amplifies these pressures by altering fungal ecology and resistance dynamics, expanding the geographic and seasonal range of thermotolerant and antifungal-resistant species, increasing fungicide use in agriculture, and intensifying cross-resistance at the human–environment interface. Urbanization, pollution and global travel compound these risks by facilitating transmission and introducing fungi into new ecological niches.

Together, these dynamics call for integrated AFS and One Health approaches that link diagnostics, treatment, surveillance and environmental management, aligned with existing AMR programmes to slow resistance and improve patient outcomes.

The COVID-19 pandemic starkly demonstrated many of these vulnerabilities, revealing how fragile global systems are when facing concurrent health threats. Surges in COVID-19-associated mucormycosis and aspergillosis exposed critical weaknesses in infection prevention and control, diagnostics and equitable access to antifungal treatment *(22,23)*.

Despite the scale and severity of the problem, fungal disease remains largely absent from national health plans, global burden-of-disease estimates, and the majority of AMR, universal health coverage (UHC), and One Health strategies. This persistent neglect, coupled with the rising threat of AFR, demands urgent, coordinated action across global, regional and national levels.

2 Rationale, purpose and target readership

In recent years, several milestones have advanced the global agenda on fungal disease and AFR. The inclusion of selected deep mycoses in the neglected tropical diseases (NTDs) portfolio, and growing attention to fungal infections within HIV and AMR surveillance frameworks have helped elevate their visibility. The 2022 launch of the *World Health Organization (WHO) fungal priority pathogens list to guide research, development and public health action* (FPPL) *(24)* marked a major advance, identifying fungal pathogens of greatest concern, including those associated with AFR – and providing a foundation for coordinated action.

Despite this progress, significant operational gaps persist (Box 1) *(25)*. Many countries, particularly LMICs, face entrenched barriers such as limited awareness and training, under-resourced laboratories, restricted access to antifungal medicines, workforce shortages, and fragmented surveillance systems. Practical guidance to translate the FPPL into action remains limited, and the growing complexity of fungal disease epidemiology demands a coordinated, multisectoral response. Without such direction and sustained investment, the momentum generated by the FPPL risks stalling before it delivers lasting global impact.

This implementation guidance responds to repeated requests from Member States, regional bodies and global partners – expressed through public consultations, expert roundtables, peer-reviewed papers, and technical dialogues – for practical guidance to operationalize the FPPL and strengthen national and regional responses to fungal disease and AFR. Developed through broad engagement across WHO regions, this implementation guidance provides a structured operational framework to support countries in strengthening coordinated national responses to fungal disease and AFR, building on the WHO FPPL and remaining adaptable to diverse contexts and health system capacities.

Box 1. Key system gaps and barriers in the global response to fungal disease and antifungal resistance

 **Governance and visibility**	• **Limited awareness and political priority:** Fungal disease and antifungal resistance remain low on global and national health agendas due to limited visibility among policy-makers, health professionals and the public. • **Fragmented and siloed responses:** Current initiatives are dispersed across disconnected programmes (e.g. AMR, NTDs, HIV), lacking a unified strategy, coordination and oversight. • **Exclusion from burden metrics and financing frameworks:** Fungal diseases are largely absent from global burden-of-disease estimates, AMR assessments, and major funding mechanisms, constraining political traction and investment.
 **Workforce, knowledge, and research capacity**	• **Knowledge and training gaps:** Mycology is underrepresented in medical, laboratory and public health curricula, contributing to misdiagnosis and delayed care. • **Limited basic and clinical research capacity:** Many countries lack institutional and human resource capacity for mycology research, clinical trials and translational science. • **Limited public and community engagement:** Low awareness and stigma delay care-seeking and perpetuate underdiagnosis. • **Underprioritized pathogens:** Some clinically important fungi, such as *Aspergillus flavus* and terbinafine-resistant *Trichophyton* spp., are not included in the FPPL and other prioritization programmes leading to underinvestment and limited research attention despite their growing regional importance.

Data, surveillance, and innovation deficits

- **Surveillance and reporting gaps:** Most fungal infections are not reportable or notifiable; antifungal resistance data remain fragmented and inconsistent.
- **Diagnostic innovation gaps:** There is a critical lack of validated, affordable, near–point-of-care and molecular diagnostic tools for fungal infections, particularly for diseases prevalent in low-resource settings.
- **Research and innovation deficits:** Research and development (R&D) for fungal disease is underfunded, with limited pipelines for new therapeutics, diagnostics and vaccines.
- **Access to new innovations:** Even when advanced tools, such as molecular diagnostics or novel antifungals, become available, high costs and regulatory barriers delay their introduction in LMICs.
- **Disrupted access during emergencies:** The COVID-19 pandemic revealed major resilience gaps in fungal disease surveillance, diagnostics, and IPC systems.

Diagnostics, treatment, and access barriers

- **Diagnostic limitations:** Fungal diagnosis remains difficult even in well-resourced settings; in many LMICs, access to fungal culture, antigen testing and antifungal susceptibility testing (AFST) is minimal.
- **Treatment access constraints:** The range of available antifungal treatments is limited, and newer agents are often expensive, unavailable in LMICs, or excluded from essential medicine lists and/or insurance schemes.
- **Weak regulation and quality assurance:** Substandard or falsified antifungal medicines and products circulate in some markets, undermining treatment outcomes.
- Non-prescription use of antifungals, including topical and oral medicines, contributes to antifungal resistance and complicating stewardship efforts.
- **Supply chain fragility:** Procurement delays and fragmented logistics lead to stockouts and interruptions in both diagnostics and therapeutics.
- **Self-perpetuating cycle:** Considered together, these barriers sustain underdiagnosis, poor surveillance, and limited recognition of the true burden of fungal disease.

Health system, IPC and stewardship gaps

- **IPC gaps:** Many countries lack standardized IPC protocols, trained personnel and preparedness plans for fungal outbreaks.
- **AMS/AFS gaps:** Stewardship programmes remain limited in scope, poorly integrated with AMR initiatives, and under-resourced in most LMICs.
- **Limited integration into primary health care:** Care for invasive and systemic fungal disease is often confined to tertiary centres, delaying diagnosis and missing early intervention opportunities – particularly for HIV-associated fungal disease.
- **Health system capacity constraints:** Weak coordination, inadequate infrastructure and limited financing constrain implementation and sustainability of fungal disease programmes.

Social and environmental determinants

- **Social determinants and vulnerabilities:** Poverty, inadequate housing, displacement, gender inequities, and occupational exposure all increase vulnerability to fungal disease.
- **Occupational and environmental exposures:** Risks from soil, vegetation and workplace environments and air quality remain poorly characterized and under-monitored.
- **Climate and environmental dynamics:** Shifts in climatic conditions, land use, and urban expansion, along with pollution and intensified population mobility, are altering fungal ecological niches, modifying virulence and transmission patterns, and facilitating the wider spread of fungal pathogens.
- **Environmental selection pressures:** The regulated yet widespread application of azole and azole-like antifungal agents in agriculture generates substantial environmental reservoirs of selective pressure, contributing to the emergence, persistence, and cross-sectoral transmission of antifungal resistance.

2.1 Objectives of the implementation guidance

The WHO fungal priority pathogens list implementation guidance aims to strengthen national and regional responses to fungal disease and AFR by translating global priorities into feasible, sequenced and context-adaptable actions.

- Translate and operationalise global priorities into national and regional action, enabling stakeholders to address critical gaps in diagnostics, treatment, surveillance, research and workforce capacity, with particular focus on low-resource settings.
- Define and sequence feasible, scalable interventions that respond to the needs of vulnerable and high-risk populations across diverse settings.
- Ensure coherence with WHO normative guidance and alignment with global strategies, including the updated *Global action plan on antimicrobial resistance (26)* and the *WHO Fourteenth General Programme of Work 2025–2028 (27)*.
- Support countries and partners in prioritizing investments, strengthening innovation pathways and coordinating multisectoral responses within existing health, AMR and One Health frameworks.

2.2 Target readership

- National policy-makers and programme managers responsible for communicable disease prevention and control, AMR and broader health system strengthening.
- Researchers and developers of antifungal medicines and diagnostics, including pharmaceutical and diagnostic companies and research institutions.
- Research funders and public–private partnerships focused on R&D of antimicrobials and other prevention and control tools.
- Global decision-makers, health providers and patient advocates.

3 Approach and development process

This implementation guidance presents feasible and scalable interventions aligned with country priorities, existing WHO guidance, and broader global health system and development goals. A summary of the development process and the core system-level gaps that informed the guidance is provided in Box 2 and Annex 1.

The outcomes of this process, together with the strategic priorities and corresponding actions, form the foundation of the guidance. They align with overarching health and AMR frameworks and translate identified gaps and opportunities into practical directions for coordinated action.

Box 2. Development process and approach[a]

Step		Description
1	**Concept development, framework design and governance**	Initial framework aligned with WHO FPPL report *(28)* recommendations, and other WHO AMR, NTD, HIV and UHC strategies, organizing work into four domains. Steering Group established and concept validated through early expert review.
2	**Stakeholder engagement: Gap identification and intervention mapping**	Series of eight online expert roundtables with representation from across all six WHO regions. Identified technical and knowledge gaps, and proposed relevant interventions covering diagnostics, treatment, surveillance, regulation and public health.
3	**Feasibility–impact assessment**	Review and scoring of proposed actions against public health impact, operational feasibility and scalability to inform sequencing and prioritization.
4	**Consensus-based prioritization**	In-person global technical consultation applying structured scoring and facilitated discussion to validate and finalize the set of priority interventions.
5	**Implementation framework and strategic mapping**	Development of a shared logic model linking interventions to outputs, outcomes and long-term impact, forming the basis for the roadmap and monitoring framework.
6	**Finalization and review**	Synthesis of all inputs, internal WHO review, and peer/public consultation, with refinements incorporated into the final draft guidance.

[a] This document was developed through expert consultation, evidence synthesis and structured prioritization processes. As implementation guidance, it does not provide normative clinical or regulatory recommendations, but rather aims to support countries and partners in operationalizing existing WHO strategies and priorities.

4 Priority actions and implementation framework

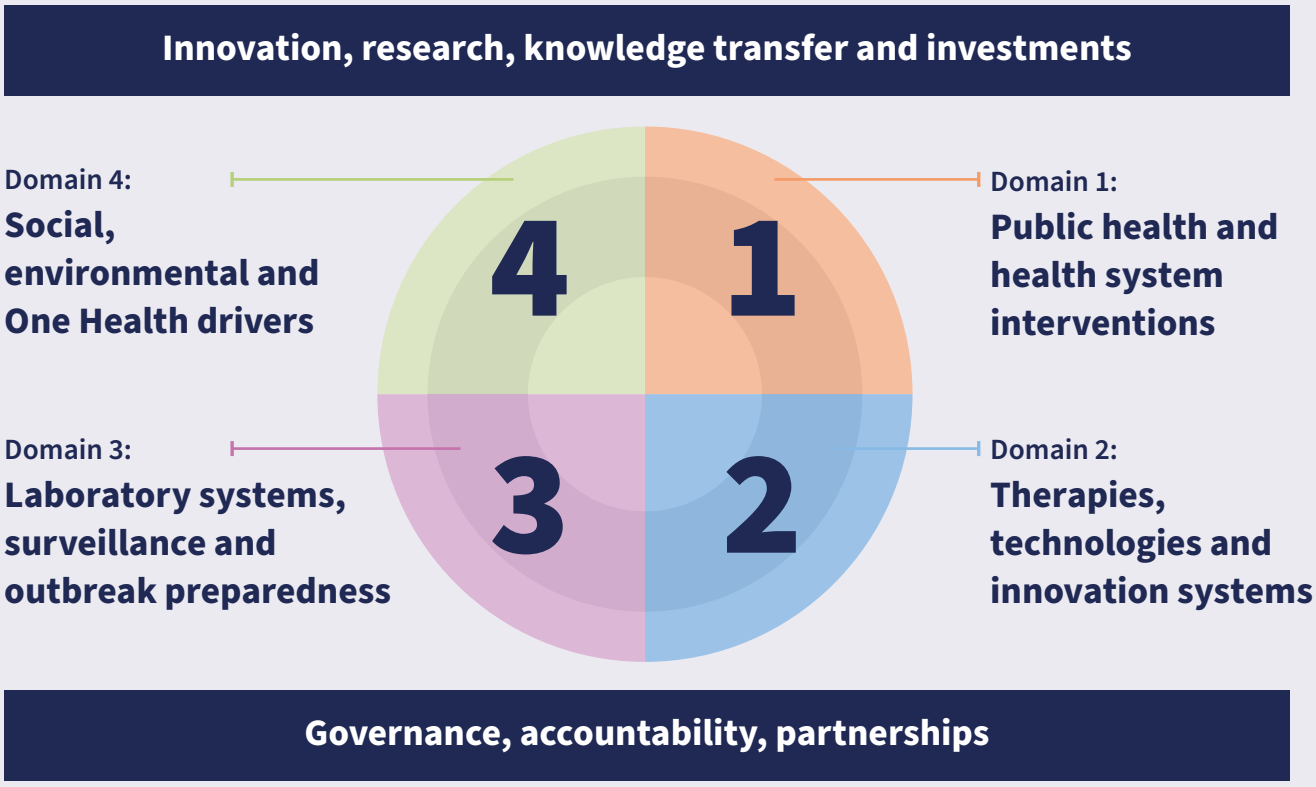
This section outlines priority actions organized under four interconnected domains that together form an implementation framework for strengthening responses to fungal disease and AFR (Figure 1). The domains provide an organizing framework for identifying and prioritizing actions to address health system, policy and knowledge gaps identified through expert consultation and feasibility assessment, while remaining aligned with WHO AMR strategies, One Health coordination mechanisms and UHC frameworks *(28-30)*.

Together, these actions provide a structured set of implementation options that countries can adapt to strengthen national responses to fungal disease threats.

The actions span both immediately implementable measures and longer-term system strengthening efforts, enabling countries to begin implementation through existing national programmes while progressively expanding laboratory, regulatory and multisectoral capacity.

Tables 1–4 present the detailed action framework across the four domains and their respective subdomains.

Figure 1. Implementation framework showing the four domains and cross-cutting enablers for strengthening responses to fungal disease and antifungal resistance



Domain 1:

Public health and health system interventions

This domain focuses on strengthening routine health service delivery for the prevention, diagnosis and management of fungal disease and AFR. Its focus is on integrating fungal disease recognition, antifungal stewardship and equitable access to essential diagnostics and medicines into routine health services.

Under-detection of fungal disease and AFR is driven by low diagnostic suspicion, inconsistent implementation of antimicrobial stewardship guidance and limited access to affordable quality-assured diagnostics and medicines. The actions under this domain address these gaps through structured awareness strategies, institutionalized infection prevention and control, formalized antifungal stewardship programmes and inclusion of antifungal medicines and diagnostics within national essential lists and financing systems.

Implementation should improve early clinical recognition, promote guided antifungal use, reduce inappropriate prescribing and expand equitable access to affordable quality-assured diagnostics and medicines, particularly for high-risk populations.

Table 1. Domain 1 priority actions: Public health and health system interventions

Sub-domain	Priority actions
1. Awareness, risk recognition and health workforce education	1. Develop and implement coordinated public awareness strategies aligned with WHO and Quadripartite AMR guidance and priorities *(31,32,33)*. 2. Integrate fungal disease and antifungal resistance content into pre-service, in-service and continuing education for health care and laboratory professionals, aligned with national training curricula and competencies. 3. Develop policy briefs that position fungal disease and antifungal resistance within AMR, HIV, TB, oncology and neglected tropical disease agendas to inform policy, planning and resource allocation.
2. Infection prevention and control (IPC) and clinical case management	4. Integrate fungal infection prevention and control (IPC) and clinical case management into existing AMR, HIV, TB and other relevant programmes. 5. Adapt and implement WHO IPC Core Components *(33)* for fungal disease prevention. 6. Develop and institutionalize national IPC and case management guidance informed by local epidemiology and system capacity with defined implementation and monitoring indicators. 7. Embed IPC and case management standards into training, supervision and monitoring systems.

Table 1 (continued). Domain 1 priority actions: Public health and health system interventions

Sub-domain	Priority actions
3. Antifungal stewardship	8. Integrate antifungal stewardship (AFS) into national AMR, HIV, TB, oncology, transplant and other relevant programmes, with explicit attention to high-risk populations. 9. Leverage existing antimicrobial stewardship training, supervision and monitoring systems to expand antifungal stewardship coverage. 10. Develop and institutionalize context-specific AFS guidelines aligned with WHO AMR stewardship frameworks *(34)*. 11. Embed antifungal and diagnostic stewardship principles into health care worker training and clinical decision-support tools. 12. Define and monitor pragmatic antifungal stewardship quality indicators aligned with existing AMR stewardship metrics to guide quality improvement and programme performance. 13. Establish and strengthen multidisciplinary stewardship teams adapted to local capacity.
4. Service-level equitable access to quality-assured diagnostics and medicines	14. Include priority antifungal medicines in national Essential Medicines Lists and reimbursement packages aligned with local disease burden. 15. Include quality-assured fungal diagnostics, including antifungal susceptibility testing (AFST), in national Essential Diagnostics Lists and laboratory tiering strategies. 16. Expand antifungal coverage within universal health coverage and insurance schemes, prioritizing vulnerable populations. 17. Strengthen forecasting, procurement and distribution systems to ensure continuous supply and prevent stockouts. 18. Utilize pooled procurement and regional collaboration mechanisms to improve affordability and supply resilience. 19. Monitor affordability, availability and distribution equity indicators to inform procurement, pricing and financing decisions. 20. Embed equity-oriented financing mechanisms to reduce financial barriers to antifungal medicines and diagnostics.

Domain 2:

Therapies, technologies and innovation systems

This domain focuses on strengthening the pathways that link antifungal innovation to equitable patient access. It emphasizes aligning research priorities with the WHO Fungal Priority Pathogens List while also supporting research on regionally important and neglected fungal disease, including multidrug-resistant dermatophytosis and other high-burden infections that remain underrepresented in global research agendas. The domain further prioritizes strengthening clinical trial participation across diverse settings, improving regulatory efficiency and supporting sustainable investment and market conditions for antifungal medicines and diagnostics.

Barriers to timely and affordable access are frequently regulatory, financing and market-related rather than scientific alone. The actions under this domain therefore focus on strengthening regulatory pathways, pharmacovigilance capacity and market-shaping mechanisms, while improving coordination between global innovation initiatives and national regulatory, procurement and reimbursement systems to enable timely introduction and sustainable access to both new and existing antifungal medicines and diagnostics *(35)*.

These actions aim to shorten regulatory approval timelines, strengthen safety oversight, expand participation of low- and middle-income countries in antifungal clinical trials and support predictable, sustainable introduction of antifungal medicines and diagnostics.

Table 2. Domain 2 priority actions: Therapies, technologies and innovation systems

Sub-domain	Priority actions
1. Research prioritization and translational research alignment	1. Align national and global research and development investments with the WHO Fungal Priority Pathogens List and other relevant global and regional priority-setting initiatives for fungal disease. 2. Support development and clinical evaluation of antifungal agents that meet WHO innovation criteria for novel antifungals, in order to reduce the risk of cross-resistance and slow resistance emergence.[a] 3. Advance translational research on host–pathogen interactions and optimization of existing antifungal agents in high-risk populations. 4. Promote prevention-focused research, including affordable diagnostics and early-stage vaccine development.
2. Clinical trial capacity and equitable participation	5. Expand multinational clinical trial networks with equitable participation of low- and middle-income countries. 6. Simplify trial protocols to facilitate implementation in resource-constrained settings. 7. Apply adaptive trial methodologies and standardized endpoints to accelerate evaluation of antifungal interventions.

Table 2 (continued). Domain 2 priority actions: Therapies, technologies and innovation systems

Sub-domain	Priority actions
3. Regulatory efficiency, safety oversight and early access	8. Implement regulatory reliance and joint review mechanisms to reduce approval timelines for antifungal products. 9. Strengthen National Regulatory Authority capacity for antifungal product evaluation, pharmacovigilance and quality control.[b] 10. Establish transparent timelines for national product registration and ethical review processes. 11. Create structured early-access pathways to enable timely access to promising antifungal medicines and diagnostics.
4. Market shaping and sustainable financing	12. Establish push and pull incentive mechanisms, including stage-gated financing models, to support development and sustainable market entry of antifungal medicines and diagnostics. 13. Develop public–private partnerships with enforceable access and affordability provisions. 14. Utilize pooled financing and existing AMR, HIV and NTD platforms to support sustainable introduction of antifungal products.
5. Introduction and equitable uptake of new and existing antifungal medicines and diagnostics	15. Align introduction of new and existing antifungal medicines and diagnostics with WHO normative listing processes and national reimbursement updates. 16. Apply tiered pricing and pooled procurement mechanisms to enhance affordability and supply stability. 17. Monitor uptake, affordability and equitable distribution of newly introduced antifungal products.
6. Knowledge sharing and data transparency	18. Require open-access publication of publicly funded antifungal research outputs. 19. Establish interoperable research and surveillance data-sharing platforms linked to WHO systems.

[a] WHO innovation criteria for novel antifungal agents include: Belonging to a new chemical class distinct from existing antifungal agents; acting on a new biological target not addressed by currently available treatments; demonstrating a new mode of action; and/or showing absence of cross-resistance to existing antifungal agents.

[b] Pharmacovigilance includes systematic monitoring of adverse drug reactions, toxicity, safety signals and clinically significant drug–drug interactions associated with antifungal medicines.

3

Domain 3:

Laboratory systems, surveillance and outbreak preparedness

This domain focuses on strengthening laboratory systems and surveillance as core components of effective responses to fungal disease and AFR. It aims to establish the diagnostic and surveillance capacity required to support clinical management, inform public health decision-making and enhance outbreak preparedness.

Insufficient diagnostic coverage, inconsistent quality assurance and limited integration of fungal pathogens into national surveillance systems constrain accurate burden estimation and timely detection of emerging resistance patterns. Strengthening laboratory and surveillance capacity is therefore essential to ensure that fungal disease and AFR are systematically detected, monitored and incorporated into national health planning.

This domain prioritizes development and strengthening of tiered laboratory networks with defined roles at peripheral, intermediate and reference levels, including capacity for fungal diagnostics and antifungal susceptibility testing. It promotes integration of fungal pathogens and AFR into existing national and global surveillance platforms, including antimicrobial resistance systems such as WHO's Global Antimicrobial Resistance and Use Surveillance System (GLASS) *(36)*. It further supports inclusion of relevant fungal infections in outbreak preparedness frameworks and response protocols and reinforces the role of WHO Collaborating Centres in supporting regional technical capacity, quality assurance and coordination.

These actions aim to enable countries to generate reliable and actionable data on fungal disease burden and resistance trends, improve early detection and response to outbreaks, and use surveillance evidence to guide management, policy, planning and resource allocation.

Table 3. Domain 3 priority actions: Laboratory systems, surveillance and outbreak preparedness

Sub-domain	Priority actions
1. Tiered laboratory capacity and quality assurance	1. Include fungal diagnostics in national Essential Diagnostics Lists and laboratory tiering strategies. 2. Expand national and regional laboratory capacity at reference and sentinel sites through tiered referral networks.[a] 3. Establish national or regional reference centres to provide confirmatory testing and external quality assessment. 4. Develop standardized technical packages and certification pathways to strengthen laboratory workforce capacity.

Table 3 (continued). Domain 3 priority actions: Laboratory systems, surveillance and outbreak preparedness

Sub-domain	Priority actions
2. Integrated Surveillance Systems	5. Incorporate fungal pathogens and antifungal resistance into national Antimicrobial Resistance (AMR) surveillance platforms. 6. Report fungal AMR data to the WHO Global Antimicrobial Resistance and Use Surveillance System (GLASS) *(36)*. 7. Harmonize case definitions, indicators and data standards across jurisdictions. 8. Utilize digital tools for real-time data capture and visualization. 9. Facilitate regional data sharing and cross-border collaboration. 10. Coordinate with environmental and One Health surveillance systems where relevant. 11. Promote targeted use of genomic and molecular surveillance through regional or reference laboratory networks to support detection of emerging antifungal resistance, outbreak investigation and cross-border transmission monitoring, building on existing sequencing platforms where feasible.
3. Outbreak Preparedness and Response	12. Develop standardized fungal outbreak response protocols, including for *Candidozyma auris (Candida auris)*. 13. Integrate fungal threats into national emergency preparedness and disaster response plans. 14. Train rapid-response teams and conduct simulation exercises. 15. Establish multisectoral coordination mechanisms for outbreak detection and response.
4. Data use for policy and planning	16. Link laboratory and surveillance data with national health information systems. 17. Develop dashboards and analytic tools to generate actionable indicators on fungal disease burden and resistance trends. 18. Train programme managers to translate surveillance data into policy and resource allocation decisions. 19. Support inclusion of fungal disease and antifungal resistance in global burden assessments.

[a] Sentinel surveillance refers to phased implementation through selected representative facilities before national scale-up.

4

Domain 4:

Social, environmental and One Health drivers

This domain addresses upstream determinants that influence fungal disease epidemiology and AFR beyond the clinical setting.

Environmental exposures, occupational risk, agricultural fungicide use and climate variability affect resistance dynamics and disease patterns. The actions under this domain integrate fungal disease and AFR considerations into housing standards, occupational health policies, agricultural regulation and climate-informed health planning. They promote coordination through national One Health mechanisms aligned with the Quadripartite AMR framework *(37)*.

Although many interventions require sustained cross-sectoral coordination, they are critical for strengthening long-term resilience and supporting prevention of AFR emergence and spread.

Table 4. Domain 4 priority actions: Social, environmental and One Health drivers

Sub-domain	Priority actions
1. Social and occupational risk reduction	1. Integrate fungal disease and antifungal resistance risk considerations into housing standards, workplace safety regulations and humanitarian response frameworks. 2. Establish occupational exposure prevention measures for high-risk sectors. 3. Incorporate fungal disease and antifungal resistance risk assessment into displacement and disaster preparedness planning.
2. Environmental risk management and resilience	4. Integrate fungal disease and antifungal resistance considerations into disaster preparedness, emergency response and climate resilience strategies. 5. Strengthen collaboration with environmental and agricultural authorities consistent with the Quadripartite One Health framework *(29)*. 6. Support monitoring of antifungal residues and relevant environmental risk factors.

Table 4 (continued). Domain 4 priority actions: Social, environmental and One Health drivers

Sub-domain	Priority actions
3. One Health coordination and cross-sector governance	7. Integrate antifungal stewardship considerations across human, agricultural and veterinary sectors through national One Health coordination mechanisms aligned with the Quadripartite AMR guidance *(34)*. 8. Incorporate human health risk assessment into fungicide regulatory frameworks to address cross-resistance. 9. Establish cross-sector data-sharing and joint risk assessment platforms.

Cross-cutting enablers

While the four domains define priority interventions, effective implementation depends on enabling conditions that operate across all domains.

Innovation, technology development, knowledge transfer and sustained investment are required to translate research into practice, expand laboratory and regulatory capacity, and support introduction and scale-up of antifungal diagnostics and medicines in settings with highest burden.

Equally, governance, regulatory coherence, accountability mechanisms and multisectoral partnerships are essential to coordinate action across health, agriculture and environmental sectors, align fungal disease priorities within national AMR and One Health frameworks, and sustain long-term political and financial commitment.

These enabling functions are embedded within the domain-specific actions rather than functioning as standalone pillars, and should be incorporated into national implementation planning, monitoring and financing strategies.

Implementation note: Catalytic entry points for phased implementation

The domain framework presented in Tables 1–4 reflects a structured prioritization process that distilled over 130 proposed actions through feasibility–impact assessment and expert consensus into a coherent implementation framework.

Recognizing that countries may initiate implementation progressively; Table 5 identifies twelve catalytic entry points drawn from across the prioritized domains. These actions represent cross-cutting accelerators that can initiate system-level change and enable broader implementation of the full framework.

Table 5 does not introduce an additional layer of prioritization nor replace the phased sequencing guidance presented in Annex 2. Rather, it highlights catalytic entry points that can help generate early momentum as countries adapt the broader framework to national contexts. Selection and sequencing should be guided by structured national prioritization processes that consider epidemiological burden, operational feasibility, equity and resource availability.

Table 5. Catalytic entry points for staged national implementation

Domain	Catalytic Entry Points
Domain 1: Public Health and Health System Interventions	1. Integrate antifungal stewardship within national antimicrobial stewardship programmes, with explicit attention to high-risk populations.
	2. Include priority antifungal medicines in national Essential Medicines Lists and reimbursement mechanisms.
	3. Include fungal diagnostics, including antifungal susceptibility testing, in Essential Diagnostics Lists and laboratory tiering frameworks.
	4. Integrate fungal infection prevention, control and case management within existing AMR, HIV, TB and primary health care platforms, aligned with universal health coverage frameworks.
Domain 2: Therapies, Technologies and Innovation Systems	5. Align national and regional research priorities with the WHO Fungal Priority Pathogens List.
	6. Strengthen regulatory reliance mechanisms and National Regulatory Authority capacity for antifungal product evaluation and pharmacovigilance.
	7. Promote equitable participation in multinational antifungal clinical trials, including meaningful LMIC inclusion.
	8. Establish financing and incentive mechanisms that support antifungal innovation with embedded access and stewardship safeguards.
Domain 3: Laboratory Systems, Surveillance and Outbreak Preparedness	9. Incorporate fungal pathogens and antifungal resistance into national AMR surveillance systems and reporting to GLASS *(36)*.
	10. Expand tiered laboratory capacity for fungal diagnostics and antifungal susceptibility testing.
Domain 4: Social, Environmental and One Health Drivers	11. Integrate fungal disease and antifungal resistance considerations into climate-informed health planning and occupational risk frameworks.
	12. Strengthen cross-sectoral One Health coordination to address agricultural, environmental and resistance drivers.

5 Implementation logic and monitoring of progress

5.1 Overview

This section defines the implementation logic underpinning the guidance and operationalizes the paradigm shift in response to fungal disease and AFR: from fragmented, pathogen-specific efforts toward coordinated, system-integrated implementation aligned with the Global action plan on AMR *(26)* and other relevant WHO strategies.

The implementation logic links prioritized interventions (Section 4) to measurable outputs, outcomes and long-term impact. It clarifies assumptions, defines functional workstreams and establishes a results-based monitoring structure. The four domains and their cross-cutting enablers operate as mutually reinforcing components of an integrated implementation pathway.

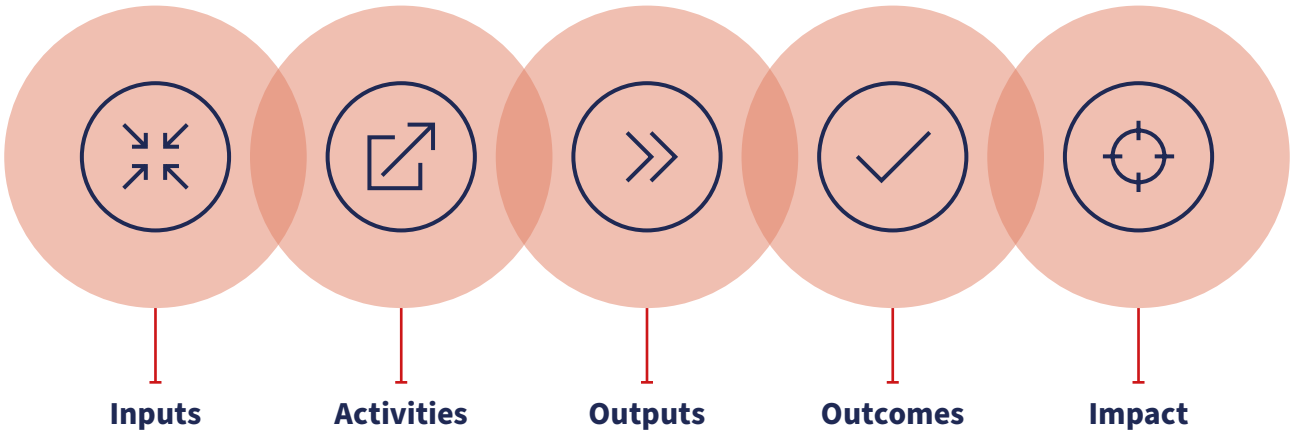
5.2 Purpose and application

The implementation logic framework serves three primary functions:

- **Strategic alignment:** Provide a common pathway of change across global, regional and national stakeholders.
- **Monitoring and evaluation:** Link inputs and activities to measurable outputs, outcomes and impact enabling tracking, course correction and accountability.
- **National planning:** Support structured adaptation of priority actions to country context, including sequencing, resource alignment and role definition.

The framework is directly derived from the prioritization process described in Annex 1 and is organized according to the same four domains. It functions as an operational backbone for implementation planning and evaluation.

Box 3. Implementation logic framework



Inputs:

Implementation requires alignment of the following enabling conditions:

- **Normative guidance:** WHO FPPL, Global action plan on AMR, strategies for UHC, NTDs and HIV.
- **Technical expertise:** WHO headquarters, regional and country offices; WHO Collaborating Centres; academic institutions; mycology societies; other partners.
- **Leadership and engagement:** Ministries of health; regulators; civil society; affected communities; patient groups; nongovernmental organizations.
- **Governance and leadership:** Ministries of health; regulatory authorities; civil society; professional societies.
- **Institutional mechanisms:** National coordination structures and accountability frameworks.
- **Existing platforms:** AMR, NTDs, HIV, TB, mycology, and essential medicines programmes.
- **Health system infrastructure:** Laboratory networks; surveillance systems; regulatory authorities; digital health tools; and supply chain mechanisms.
- **Innovation ecosystem:** Research collaborations; technology transfer; and platforms for knowledge exchange.
- **Financing:** Domestic budgets, donor funding and innovative financing mechanisms.

Activities[a]:

Inputs are translated into a core set of functional workstreams through which prioritized interventions are implemented:

- **Policy alignment and integration:** Map and align national initiatives (e.g. AMR, HIV, TB, NTD, UHC) to incorporate fungal disease and antifungal resistance priorities.
- **Capacity building:** Train health care providers; strengthen workforce competencies in diagnosis, management, stewardship and IPC.
- **Laboratory and surveillance strengthening:** Expand diagnostic capacity; integrate AFST; incorporate fungal surveillance into national and global AMR and communicable disease systems (e.g. GLASS).
- **Access and supply chain optimization:** Improve forecasting, procurement, pricing and distribution of quality-assured antifungals and diagnostics.
- **Stakeholder engagement:** Foster collaboration across ministries, regulators, civil society, patient groups and communities.
- **Global coordination for innovation and access:** Facilitate international mechanisms, including pooled financing for fungal R&D, global clinical trial platforms with LMIC participation, and regulatory reliance networks[a,b]

[a] Activities represent functional work-streams that organize and deliver the domain-specific interventions, they are not a re-statement of the interventions themselves.

[b] These activities organize implementation and do not duplicate the domain-specific actions in Tables 1–4 .

Outputs

Implementation of these activities should produce measurable outputs that demonstrate operational progress and establish core system capacities required for sustained scale-up:

- **Awareness and advocacy:** Implementation of targeted communication and advocacy initiatives that increase visibility of fungal disease and antifungal resistance and secure documented political and financial commitment.
- **Policies and plans:** Adoption or revision of national policies, strategies or action plans that explicitly address fungal disease and antifungal resistance.
- **Workforce capacity:** Deployment of trained clinical and laboratory personnel with competencies in fungal diagnosis, case management, antifungal stewardship and infection prevention and control (IPC).
- **Laboratory networks:** Establishment or strengthening of tiered laboratory systems capable of performing fungal diagnostics, including antifungal susceptibility testing (AFST), and reporting standardized data to national systems and the Global Antimicrobial Resistance and Use Surveillance System (GLASS).
- **Access mechanisms:** Sustainable inclusion of quality-assured antifungal medicines and diagnostics within essential medicines lists, formularies, reimbursement schemes and procurement systems, supported by strengthened forecasting and supply chain management.
- **Coordination platforms:** Operational national and international coordination mechanisms engaging stakeholders across health, research, regulatory and civil society sectors.
- **Cross-sectoral interventions:** Implementation of defined measures addressing climate-sensitive fungal risks, environmental exposures, housing conditions and occupational safety in high-risk settings.
- **R&D and regulation:** Increased allocation of funding for fungal research and development (R&D), strengthened regulatory reliance mechanisms and enhanced pharmacovigilance systems for antifungal products.

Outcomes

These activities should produce measurable outputs that demonstrate operational progress and establish core system capacities required for sustained scale-up:

- **Heightened awareness and prioritization:** Fungal disease and antifungal resistance gain visibility in public health agendas, securing political commitment and resources.
- **Integration into health programmes:** Fungal prevention, diagnosis and treatment embedded into AMR, HIV, TB, NTD and UHC programmes.
- **Improved equitable access to antifungal medicines and diagnostics:** supported by strengthened clinical capacity and awareness, enabling earlier detection and optimal case management.
- **Strengthened diagnostic capacity, laboratory and surveillance systems:** Strengthened diagnostic capacity, laboratory and surveillance systems, supported by robust infrastructure and interoperable data platforms, generate reliable national and global information to guide case management, inform action and ultimately save lives.
- **Broader stewardship and IPC practices:** Antifungal stewardship and IPC are applied more consistently across health facilities.
- **Data-driven decision-making:** Increased generation and use of high-quality burden and resistance data inform national policies and global strategies.
- **Enhanced global coordination:** Stronger international collaboration ensures timely data-sharing, joint responses and coherent policy action.
- **A more needs-driven innovation pipeline:** Coordinated funding and inclusive research platforms support equitable access to new diagnostics and antifungal medicines.

Impact

Long-term impact includes sustained reduction in fungal disease burden and strengthened health system capacity to prevent, detect and respond to antifungal resistance:

- **Improved awareness** of the global significance of fungal disease and antifungal resistance.
- **Reduced burden:** Reduced morbidity and mortality from fungal disease.
- Slowed emergence and spread of antifungal resistance.
- Reduced inequities in access to diagnosis and treatment.
- **Resilience:** Increased health system resilience to climate-sensitive and emerging fungal threats across settings.

6 National adaptation and priority-setting

Implementation requires structured national adaptation. Countries are encouraged to undertake epidemiological and health system assessments to define national fungal disease and AFR priorities, and to align national priority pathogen lists or adaptation frameworks with WHO methodologies where appropriate. Sequencing of actions should be informed by structured assessments of feasibility, equity and available resources, ensuring that implementation reflects national capacity and burden. Fungal priorities should be embedded within existing AMR, UHC and communicable disease platforms to maximize integration and sustainability. Monitoring indicators should be aligned with the implementation logic described in Section 5 to support accountability and course correction.

Table 5 identifies catalytic entry points that may support early implementation. Annex 2 provides indicative sequencing guidance across implementation phases. Neither replaces national priority-setting processes.

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Annexes

Annex 1. Methodology and development process

This annex summarizes the methodology and development process underpinning the implementation guidance. It describes how priorities were identified, validated and refined through expert consultations, feasibility–impact assessment and consensus-based prioritization. All external contributors declared relevant interests, which were managed in accordance with WHO conflict-of-interest policies.

1.1 Initial framework, governance and proof of concept

Development of the implementation guidance began with a conceptual framework grounded in existing WHO strategies and normative guidance related to AMR, UHC, neglected tropical diseases and other relevant programmes. This framework organized the priority areas into four strategic domains: public health interventions; advancement of therapies, tools, and innovation; laboratory systems, surveillance, and outbreak response; and social and environmental drivers, including One Health dimensions. To guide the process, WHO convened a steering group comprising technical staff from WHO headquarters and regional offices, members of the FPPL Advisory Group and cross-programmatic experts. The draft framework was presented during a proof-of-concept workshop at the 2024 Congress of the European Society of Clinical Microbiology and Infectious Diseases (ESCMID) in Barcelona. At this workshop, 25 global experts reviewed and validated the framework as a practical structure for implementation and agreed that it provided a coherent foundation for identifying and prioritizing actions to strengthen responses to fungal disease and AFR.

1.2 Roundtable consultations

Building on the validated framework, WHO convened eight expert- and stakeholder-led virtual roundtables in 2024 to identify system-level gaps, define priorities and propose actionable interventions across the four domains of the implementation guidance. More than 150 participants contributed, representing a broad range of expertise including clinical mycology, diagnostics, antifungal stewardship, surveillance, regulatory policy, procurement, public health and patient advocacy. Participation reflected disciplinary diversity, gender balance and representation across all six WHO regions.

The roundtables generated over 130 proposed actions. These were mapped to 13 thematic areas aligned with the domain structure and subsequently reviewed, clustered and refined by the WHO Secretariat with technical input from participants and internal WHO experts. This process included identification and validation of systemic barriers that have historically limited progress in fungal disease prevention and AFR mitigation, ensuring that prioritized actions directly addressed key implementation constraints within health systems.

1.3 Synthesis of roundtable outputs and feasibility–impact assessment

Following the roundtable consultations, WHO conducted a structured feasibility–impact assessment of all proposed actions to inform prioritization and sequencing. Each action was evaluated across three dimensions: public health impact, operational feasibility, and scalability and adaptability across country contexts.

Actions were classified as high, moderate or low feasibility (Box 4). The definitions used for these categories are provided below. This classification provided a structured basis for identifying catalytic entry points and for distinguishing actions that could be implemented within existing systems from those requiring longer-term structural investment. The assessment informed the prioritization reflected in Tables 1–4 and the catalytic entry points presented in Table 5. The assessment also underpins the sequencing guidance presented in Annex 2.

Note: Feasibility was used for categorical classification; however, impact and scalability were weighted equally in determining strategic relevance and implementation timing. High-impact actions, particularly those benefiting high-burden or vulnerable populations and those adaptable across settings, were prioritized for earlier implementation.

Box 4. Feasibility definitions used in prioritization

High feasibility:

Actions that can be implemented using existing infrastructure, policies or systems, with limited political, financial or logistical barriers.

Moderate feasibility:

Actions that are achievable but require additional coordination, resource mobilization, policy alignment, stakeholder engagement, advocacy or adjustment to existing frameworks.

Low feasibility:

Actions that require substantial systemic change, sustained resource commitments or significant institutional reform, and therefore face considerable implementation barriers.

Note: Feasibility classification does not imply lower strategic importance. High-impact or highly scalable actions may be prioritized even if feasibility is moderate, particularly where cross-sectoral benefits or equity considerations apply.

1.4 Technical consultation and consensus-based prioritization

The feasibility–impact assessment informed a global technical consultation convened by WHO in October 2024. The two-day hybrid consultation engaged more than 50 participants, including representatives from WHO headquarters and regional offices, ministries of health, academic institutions, civil society, scientific societies and technical partners.

The consultation reviewed and refined the prioritized actions identified through the roundtables and feasibility assessment. Participants examined proposed interventions in breakout groups and plenary sessions, assessing feasibility, impact and scalability. Structured digital polling supported transparent prioritization. The process resulted in a consolidated set of prioritized actions across the four domains, reflecting expert consensus and operational implementability.

Annex 2. Implementation phasing guide

2.1 Purpose and use

This annex provides indicative sequencing guidance to support national implementation planning. While the implementation logic framework (Section 5) explains how change is expected to occur, this annex outlines broad implementation phases to assist countries in determining sequencing according to capacity, resource availability and institutional readiness. It should be read in conjunction with Table 5, which identifies catalytic entry points but does not define implementation phases.

This phasing framework is illustrative and non-prescriptive. Countries should adapt sequencing to national context and priorities. The guide is intended to support alignment of technical assistance, financing and national milestones.

2.2 Implementation phases

The three phases were informed by the prioritization and feasibility–impact assessment described in Annex 1. They reflect relative implementation complexity rather than fixed timelines.

Phase I (short-term):

I

High-feasibility, high-impact actions that can be initiated within existing systems and infrastructure.

Phase II (medium-term):

II

Actions requiring moderate investment, policy alignment or cross-programmatic coordination.

Phase III (long-term):

III

Structural or multisectoral actions requiring sustained resource commitments and institutional reform.

These definitions are indicative. Countries should adapt them based on local circumstances rather than fixed timelines.

Table A1. Illustrative sequencing of domain priority areas by implementation phase

Domain/ Sub-domain	Priority Area Summary	Phase
1.1 & 2.1	National campaigns, health care worker and community awareness and education, National priority-setting research for definition and alignment with fungal disease and antifungal resistance burden and population needs	I
1.2 & 1.3	IPC/stewardship guidance, facility-level practices, integration with AMR/NTD/HIV	I–II
1.4, 2.5 & 2.6	Forecasting, procurement, supply chain strengthening, access strategies	II–III
2.1, 2.3 & 2.5	Incentives, streamlined market approval, aligned funding with FPPL priorities	II–III
2.2 & 2.5	Optimized trial networks, prevention-focused R&D, South–South collaboration	II
2.2 & 2.5	Data-sharing commitments, equitable licensing, global transparency tools	II–III
3.1	National diagnostic expansion, WHO collaborating centres, lab tiering	I–II
3.2 & 3.4	Integrated reporting systems, GLASS inclusion, data harmonization	II
3.3	Protocol development, fungal outbreak simulation, preparedness plans	II–III
4.1 & 4.2	Built environment resilience, community-level risk reduction, humanitarian linkage	III
4.2 & 4.3	Cross-sectoral AMR strategies, environmental surveillance, climate sensitivity	III

Notes: This sequencing is non-binding and provided for illustration only. Countries and partners are encouraged to adapt and localize sequencing according to national priorities, institutional readiness, and resources. Milestones and success indicators aligned with these phases should be co-developed during country implementation planning. Alternative classification models (e.g. by complexity/dependency or enabling conditions) have been suggested and could be explored in future revisions.

Annex 3. Areas for further research and outstanding questions

A critical component of the blueprint is the identification of research areas that can close persistent evidence gaps, accelerate innovation, and inform effective policy and programmatic responses. Fungal disease and AFR remain significantly under-studied, particularly in low- and middle-income countries (LMICs), where diagnostic and treatment capacity is often limited.

This annex complements the WHO AMR research priority agendas for human health and One Health by highlighting fungal-specific priorities that remain underrepresented *(1, 2)*. The questions presented in Table A2 are not exhaustive but illustrate areas where further evidence is urgently needed. They are framed to guide research funders, policy-makers, and academic partners toward activities that can generate impact across health systems, especially in resource-limited contexts.

Table A2a. Understanding the problem

Research areas	Guiding research questions
Disease burden and epidemiology	How can global burden of disease estimates more accurately reflect incidence, mortality, and DALYs associated with fungal disease across diverse populations?
Diagnostics and surveillance interdependence	How can expanded access to affordable diagnostics and strengthened surveillance systems be combined to generate reliable epidemiological data on fungal disease? How can AFST methods be standardized, simplified and made less labour-intensive to enable broader implementation across diverse laboratory settings?
Vulnerabilities and determinants	What are the key social and environmental drivers of fungal disease risk – such as expanding at-risk clinical populations, climate change, migration, housing and occupational exposure – and how can they be quantified and mitigated?

Table A2b. Detection and diagnosis

Research areas	Guiding research questions
Advance patient-centred, near-patient diagnostics for fungal disease and antifungal resistance	What affordable, reliable and easy-to-use diagnostic tools can support triage at community and primary care levels, and how can they be integrated with hospital-level tools for managing severe infections?
Novel and advanced technologies for fungal disease and antifungal resistance	How can next-generation sequencing, CRISPR-based assays, artificial intelligence and machine learning be adapted and scaled to improve fungal diagnostics in diverse health system contexts, including LMICs?

Table A2c. Treatment and prevention

Research areas	Guiding research questions
Clinical management and treatment guidelines	How can antifungal treatment guidelines for human infections be developed, updated and adapted for LMIC settings to optimize patient outcomes?
Optimizing antifungal use	What are the most effective and context-appropriate antifungal treatment regimens in high-burden LMIC settings, and how can stewardship be strengthened to slow resistance?
Drug discovery and pipeline development	What new antifungal compounds, targets or formulations hold the greatest potential for addressing resistant fungal pathogens?
Vaccines and immunotherapies	What innovative vaccine strategies or immune-based therapies could be developed to prevent or treat invasive fungal infections in high-risk populations?
Environmental controls	Which building materials, infrastructure designs and infection prevention measures are most effective at reducing fungal exposure in homes, workplaces and health care facilities?

Table A2d. Cross-cutting challenges

Research areas	Guiding research questions
Transmission dynamics of antifungal resistance	How does antifungal resistance spread across human, animal and environmental reservoirs, and what interventions are needed to interrupt transmission?
Cross-sectoral antifungal use	How can cross-sectoral collaboration be strengthened to prevent dual use of antifungal agents and optimize their utilization across human, animal and environmental sectors?
Equitable access models	What policy and financing mechanisms can ensure timely and affordable access to essential antifungals and diagnostics across different health system contexts?
Data sharing and collaboration	How can global platforms and networks be strengthened to facilitate timely sharing of fungal disease and resistance data across countries and sectors?

Addressing these areas for further research will accelerate innovation, improve equity and strengthen health system responses to fungal disease and AFR. Progress in these domains is essential to achieving the long-term impact envisioned in this blueprint.

References for annex 3

1. Global research agenda for antimicrobial resistance in human health. Geneva: World Health Organization; 2024 (https://iris.who.int/handle/10665/379825) CC BY-NC-SA 3.0 IGO.
2. Global research agenda for antimicrobial resistance in human health. Geneva: World Health Organization; 2024. Licence: CC BY-NC-SA 3.0 IGO. (https://www.who.int/publications/i/item/9789240102309) (Accessed on 14 November 2025).

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