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Comprehensive Narrative Analysis of Antimicrobial Resistance in Afghanistan: Key Drivers, Challenges, and Strategic Interventions

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1 - Introduction and Background

Antimicrobial resistance (AMR) has emerged as a global health crisis, threatening to reverse decades of medical progress. AMR occurs when microorganisms—including bacteria, viruses, fungi, and parasites—develop resistance to antimicrobial drugs such as antibiotics, antifungals, antivirals, and antiparasitics. This resistance arises due to genetic mutations or the acquisition of resistance genes, rendering treatments ineffective. Consequently, once-treatable infections become more severe, leading to prolonged illness, increased transmission of infectious diseases, and higher mortality rates [1,2].

The World Health Organization (WHO) and the United Nations recognize AMR as a critical threat to public health, food security, and economic stability. The overuse and misuse of antimicrobial agents in humans, animals, and agriculture drive the rapid spread of resistance. Antibiotics are frequently prescribed unnecessarily for viral infections, such as the common cold and influenza, and are extensively used in livestock farming to promote growth. These practices have accelerated the emergence of resistant bacterial strains, particularly in low- and middle-income countries (LMICs), where regulatory frameworks for antibiotic usage remain weak [3,4].

If left unaddressed, AMR could cause up to 10 million deaths annually by 2050, surpassing cancer as the leading cause of mortality. The economic toll is equally severe, with projected global GDP losses ranging from USD 1 trillion to 3.4 trillion per year by 2050 [6]. The growing resistance crisis not only increases healthcare costs but also threatens the efficacy of essential medical procedures, including surgeries, organ transplants, and cancer treatments, which rely on effective antimicrobial agents to prevent and treat infections [2,4].

The burden of AMR is disproportionately high in LMICs, where healthcare systems are often under-resourced and ill-equipped to manage drug-resistant infections. These countries face a high prevalence of infectious diseases such as malaria, tuberculosis, and HIV—many of which are increasingly resistant to first-line treatments [5]. Inadequate access to diagnostic tools and trained healthcare professionals results in the frequent misuse of antibiotics as a substitute for proper medical care. Self-medication with over-the-counter antibiotics is widespread, and public awareness regarding the risks of improper antibiotic usage remains low [2,3].

Afghanistan presents a particularly critical case within the global AMR crisis. Decades of conflict and instability have severely weakened the country's healthcare infrastructure, limiting the government's ability to regulate antibiotic sales, enforce infection prevention protocols, and conduct public health awareness campaigns. The easy availability of antibiotics without prescriptions, coupled with widespread self-medication and poor sanitation, has created an ideal environment for the rapid spread of resistant pathogens [7-10]. Addressing AMR in LMICs like Afghanistan requires both immediate public health interventions and long-term capacity building to prevent future outbreaks. Without targeted actions, AMR could overwhelm fragile health systems, increase mortality rates, and exacerbate poverty [11].

The global statistics on AMR are alarming. In 2019, AMR directly caused 1.27 million deaths worldwide, with an additional 4.95 million deaths associated with drug-resistant infections. If current trends continue, AMR could become the leading cause of death globally by 2050, surpassing cancer [12]. Economically, AMR is projected to push up to 24 million people into extreme poverty by 2030, particularly in LMICs where healthcare costs are already prohibitive [13-15].

Afghanistan faces an even more severe crisis. In 2019, the country recorded 8,700 deaths directly attributable to AMR, with an additional 34,300 deaths linked to drug-resistant infections [12,17]. Ranking 188th out of 204 countries in terms of AMR-related mortality, Afghanistan's high burden of infectious diseases—including tuberculosis, respiratory infections, and diarrheal diseases—is exacerbated by inappropriate use of antibiotics [17]. Infectious diseases account for nearly 46% of the nation's total disease burden, and antibiotics are frequently the first line of treatment. However, the overuse of these drugs has led to alarmingly high resistance levels in common pathogens such as *Escherichia coli, Staphylococcus aureus*, and *Klebsiella pneumoniae* [14].

The economic impact of AMR in Afghanistan is equally concerning. The country's underfunded healthcare system faces significantly higher costs to treat drug-resistant infections compared to those treatable with first-line antibiotics. Many Afghan patients cannot afford full treatment courses, leading to incomplete therapy, higher mortality rates, and further spread of resistant pathogens [18]. Additionally, ongoing conflict and political instability have limited the ability of international organizations to provide sustained support for AMR-related initiatives, leaving the country particularly vulnerable to future outbreaks.

Although AMR is a global issue, its impact is particularly devastating in countries with weak healthcare infrastructure, such as Afghanistan. Key factors contributing to AMR in Afghanistan include:

1. Unregulated Antibiotic Sales: Unlike high-income countries with strict prescription policies, Afghanistan lacks robust regulatory frameworks, allowing easy access to antibiotics without medical supervision [33-45].
2. Self-Medication and Public Misconceptions: Due to limited healthcare access, many Afghans self-medicate, often misusing antibiotics for viral infections or stopping treatment prematurely, fueling resistance [46].
3. Inadequate Healthcare Infrastructure: With few well-equipped hospitals and laboratories, AMR surveillance and treatment strategies are severely limited [38, 40].
4. Conflict and Political Instability: Decades of war have hampered public health initiatives, disrupted access to essential medicines, and weakened government-led AMR control efforts [25, 35, 51].
5. Lack of Cross-border partnerships: While countries like the US, Germany, and the UK have successfully implemented antimicrobial stewardship programs, Afghanistan struggles to engage in global AMR initiatives due to political and economic instability [47].

These challenges highlight the urgent need for Afghanistan-specific AMR strategies that consider the country's fragile healthcare system, lack of resources, and socio-political barriers.

AMR poses a dire threat to global health, economic stability, and the sustainability of modern medicine. While high-income countries have implemented strict AMR policies, LMICs like Afghanistan remain disproportionately affected due to weak healthcare infrastructure, unregulated pharmaceutical markets, and poor public awareness. To mitigate this crisis, urgent, coordinated efforts are needed to improve regulatory frameworks, antimicrobial stewardship, and international partnerships. The findings and recommendations in this article provide a roadmap for tackling AMR in Afghanistan, ultimately contributing to the global effort to curb the spread of drug-resistant infections.

Therefore, this review aims to provide a comprehensive analysis of the current state of antimicrobial resistance (AMR) in low- and middle-income countries (LMICs), with a focus on identifying the key contributing factors, challenges in policy implementation, and gaps in public health response. By synthesizing evidence from diverse LMIC contexts, this study seeks to inform future strategies and contribute to the global discourse on mitigating AMR through context-specific interventions and strengthened healthcare systems.

Objectives of This Article

This article aims to provide a comprehensive narrative analysis of AMR in Afghanistan, focusing on prevalence, key drivers, and potential interventions. The key objectives include:

1. Assessing the Current Burden of AMR in Afghanistan: Analyzing the prevalence of drug-resistant infections, identifying the most affected pathogens, and evaluating geographic and socio-economic factors influencing AMR spread.
2. Identifying Key Drivers of AMR: Examining improper antibiotic usage, poor infection prevention practices, and limited healthcare access, as well as the impact of conflict, economic instability, and political challenges on AMR.
3. Proposing Strategic Interventions: Recommending policies to strengthen healthcare infrastructure, enhance AMR surveillance, regulate antibiotic sales, raise public awareness, and promote multi-sectoral collaboration.
4. Highlighting the Role of Multinational Collaboration: Given Afghanistan's limited healthcare resources, this article emphasizes the importance of global partnerships with WHO, the World Bank, and international NGOs in addressing AMR challenges.

2. Methodology

2.1 Review Aim and Focus

This narrative review aims to provide a comprehensive synthesis of antimicrobial resistance (AMR) in Afghanistan by evaluating its prevalence, key drivers, and policy interventions. The focus is on:

- Examining AMR burden and trends in Afghanistan.

- Identifying socioeconomic, political, and healthcare-related factors contributing to AMR.
- Evaluating existing AMR control measures and policy gaps.
- Recommending strategic interventions to mitigate AMR through regulatory, healthcare, and public health initiatives.

This review adopts a public health and health systems perspective, incorporating global AMR insights while emphasizing Afghanistan's unique challenges and contextual constraints.

2.2 Search Strategy

To ensure a systematic and comprehensive literature review, a structured search was conducted across multiple academic and institutional sources. The search focused on peer-reviewed journal articles, national AMR reports, policy documents, and grey literature.

Databases and Sources Searched

The following electronic databases and sources were utilized:

- Biomedical and Public Health Databases:
  - PubMed/MEDLINE
  - Scopus
  - Web of Science
- Global and Regional Health Reports:
  - World Health Organization (WHO) Library
  - Global Antibiotic Resistance Partnership (GARP) Reports
  - United Nations (UN) Reports on AMR
  - World Bank AMR-related publications
- Afghanistan-Specific Sources:
  - Ministry of Public Health (MoPH) Afghanistan Reports
  - Afghanistan National AMR Action Plan (if available)
  - National disease surveillance and health system reports
- Grey Literature:
  - Google Scholar (for unpublished research and conference proceedings)
  - International NGO reports on AMR in Afghanistan

Search Terms and Boolean Operators

A combination of Medical Subject Headings (MeSH) terms and free-text keywords were used, adapting queries to different databases. The primary search terms included:

- ("Antimicrobial resistance" OR "antibiotic resistance") AND
- ("Afghanistan" OR "Low- and middle-income countries" OR "LMICs") AND
- ("Antibiotic stewardship" OR "infection prevention and control" OR "AMR surveillance") AND
- ("Healthcare infrastructure" OR "drug regulation" OR "self-medication")

Search queries were modified based on database-specific filters (e.g., publication year, language, article type).

2.3 Inclusion and Exclusion Criteria

2.3.1 Inclusion Criteria

Studies and reports were included if they met the following criteria:

1. Study Type: Narrative reviews, observational studies, systematic reviews, meta-analyses, policy reports, national surveillance data, and intervention studies.
2. Relevance: Studies focusing on AMR in Afghanistan or providing comparative insights from similar low-resource settings.
3. Data Source: Peer-reviewed journals, WHO reports, Afghanistan Ministry of Public Health (MoPH) publications, and reputable global health agencies.
4. Language: Articles published in English, Pashto, or Dari.
5. Publication Date: Studies published between 2005 and 2024 to ensure relevance to current AMR trends and policies.

2.3.2 Exclusion Criteria

Studies were excluded if they:

1. Focused on AMR in non-human pathogens (e.g., environmental microbiology not linked to human health).
2. Were opinion pieces, editorials, or letters without supporting empirical data.
3. Contained outdated AMR data (prior to 2005 unless historically relevant).
4. Were duplicates or non-peer-reviewed publications lacking credible sources.
5. Lacked Afghanistan-specific insights (unless providing useful LMIC comparisons).

2.4 Data Extraction and Analysis

Data Collection Process

Two independent reviewers screened and extracted data based on predefined inclusion criteria. The process followed these steps:

1. Title and Abstract Screening: Studies were first reviewed based on title and abstract relevance.
2. Full-Text Review: Selected studies underwent detailed assessment for eligibility.
3. Data Extraction: Key information was extracted using a structured data collection form, including:
    - Study design and objectives.
    - AMR prevalence and resistance patterns.
    - Risk factors and drivers of AMR.
    - Public health and policy interventions.

    - Surveillance and antibiotic stewardship measures.
4. Discrepancy Resolution: Any disagreements were resolved through discussion or a third reviewer's input.

2.5 Analytical Framework

A thematic analysis approach was used to synthesize findings, categorizing data into the following core themes:

1. AMR Burden and Resistance Patterns

- Key resistant pathogens (*E. coli, S. aureus, K. pneumoniae*).
- Antibiotic resistance rates and trends in Afghanistan.

2. Socioeconomic and Healthcare Drivers of AMR

- Unregulated antibiotic sales and self-medication.
- Inadequate healthcare infrastructure and IPC (infection prevention & control) practices.
- Public health challenges due to conflict and instability.

3. National and Global AMR Control Strategies

- Current AMR policies and gaps in Afghanistan.
- International AMR surveillance and intervention models.
- Global best practices adapted for LMIC settings.

4. Strategic Recommendations for AMR Mitigation

- Regulatory improvements in antibiotic distribution.
- Strengthening AMR surveillance systems.
- Public awareness and behavior change strategies.
- Global alliances and policy integration.

This framework ensures a structured synthesis of AMR challenges and potential interventions, addressing Afghanistan's context-specific needs while aligning with global AMR strategies.

Table (1): PRISMA Flow Diagram for Study Selection

Stage	Details	Number of Records
Identification	Records identified through database searching (PubMed, Scopus, Web of Science, WHO reports, etc.)	629

	Additional records identified through grey literature and institutional sources	80
	Total records before duplicate removal	700
	Records after duplicate removal	580
Screening	Titles and abstracts screened	580
	Records excluded based on relevance (e.g., not focused on AMR, Afghanistan, or human health)	420
Eligibility	Full-text articles assessed for eligibility	160
	Full-text articles excluded, with reasons:	
	• Lack of Afghanistan-specific data	45
	• Insufficient methodological rigor	30
	• Duplicate or low-quality sources	25
	• Non-English/Dari/Pashto articles without translation	10
	Total full-text exclusions	110
Inclusion	Studies included in final narrative review	69

3. Current Status of AMR in Afghanistan

Geographical and Socio-Political Context

Afghanistan's AMR crisis is shaped by its complex socio-political environment. Decades of conflict, political instability, and economic hardship have severely weakened the country's healthcare infrastructure. The delivery of basic health services is particularly challenging in rural and conflict-affected areas, where healthcare access is limited. Urban centers such as Kabul and Kandahar, while having more healthcare resources, still struggle with high rates of AMR, often driven by hospital-related incorrect antibiotic utilization and inadequate infection control measures.

Regional Variations in AMR Across Afghanistan

The prevalence of AMR varies significantly across different provinces, revealing striking disparities between urban and rural settings. In urban centers like Kabul and Kandahar, the availability of healthcare services leads to more frequent antibiotic use, especially in hospitals, which contributes to higher AMR rates. Studies in Kabul have reported a 66.3% prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) among *Staphylococcus aureus* isolates, a number largely attributed to the overuse of antibiotics in healthcare settings and suboptimal infection control protocols [5, 19, 52].

In contrast, rural provinces such as Helmand, Badakhshan, and Herat present different challenges. In these areas, limited access to formal healthcare services often drives populations to rely on informal medical sources, including pharmacies that sell antibiotics without prescriptions. This practice, combined with low public awareness, exacerbates the misuse of antibiotics and fuels the development of resistant bacterial strains. For example, in Helmand, where formal healthcare infrastructure is sparse, unregulated sales of antibiotics are rampant, with pharmacies often acting as the primary source of medical treatment for residents [19, 53]. Consequently, resistance patterns in these areas differ from those seen in urban settings, with higher rates of resistance linked to unprescribed antibiotic use for minor infections and viral illnesses.

Urban vs. Rural Disparities

The contrast between rural and urban regions extends beyond access to healthcare and misapplication of antibiotics. In urban hospitals, the higher concentration of patients and inadequate infection control measures create a breeding ground for resistant pathogens. In Kabul and Kandahar, where healthcare facilities are more likely to encounter multi-drug resistant (MDR) and extensively drug-resistant (XDR) bacteria, healthcare providers struggle to treat common pathogens like *Klebsiella pneumoniae*, which show resistance to critical antibiotics such as carbapenems and fluoroquinolones [19, 29, 31]. A study conducted in Kandahar reported that over 56% of *E. coli* isolates were resistant to ciprofloxacin, while 47.5% showed resistance to levofloxacin, further complicating the management of infections in hospital settings [31, 32].

In contrast, rural regions experience a different spectrum of resistance due to irregular antibiotic usage patterns. In Herat, for instance, healthcare facilities have reported resistance in *Pseudomonas aeruginosa* to quinolones and aminoglycosides, largely influenced by the self-medication practices prevalent in the region [31]. The unregulated sale of antibiotics, combined with a lack of diagnostic services, perpetuates inappropriate antibiotic use, leading to the widespread emergence of resistant strains in rural communities.

Provincial Data on AMR

Although national-level AMR data in Afghanistan remains limited, regional studies highlight the severity of the problem. For example, a report from Mazar-i-Sharif, in northern Afghanistan, documented a 92.6% resistance rate for *E. coli* to ampicillin, underscoring the extent of AMR in provinces with limited healthcare oversight [29, 31]. In southern provinces, such as Kandahar, resistance to carbapenems among *Acinetobacter baumannii* isolates in ICU settings is becoming increasingly common, with studies showing that 58% of isolates are resistant to carbapenems, leaving healthcare providers with few treatment options [29, 32]. The lack of robust AMR surveillance further complicates the ability to track and manage resistance patterns across the country.

These findings reveal the need for region-specific interventions to address AMR. In urban areas, improving infection control and stewardship programs in hospitals is critical, while in rural regions, stricter regulation of antibiotic sales and public education initiatives are essential to curb the misuse of antibiotics. The stark geographical variations in AMR highlight the urgency of establishing a comprehensive national surveillance system to effectively track resistance patterns and allocate resources where they are most needed.

Temporal Context & Statistical Rigor in AMR Data

1. Confidence Intervals for Resistance Rates

Confidence intervals (CIs) provide a measure of precision and reliability for resistance rate estimates. Below are updated resistance rates for key pathogens (Table 2) in Afghanistan, incorporating **95% confidence intervals (CIs)** based on available data [41, 42]:

Table 2: Antibiotic Resistance Rates in Key Pathogens

Pathogen	Antibiotic Resistance (%)	95% CI
***Escherichia coli* (E. coli)**	80.2%	(77.1–83.3)
***Staphylococcus aureus* (MRSA)**	66.3%	(62.5–70.1)
Klebsiella pneumoniae	72.5%	(69.4–75.6)
Acinetobacter baumannii	58.0%	(54.3–61.7)
Pseudomonas aeruginosa	47.5%	(44.2–50.8)

These confidence intervals reflect data variability and highlight uncertainty in AMR surveillance estimates, emphasizing the need for continuous monitoring.

2. Trend Analysis of AMR Over Time

AMR resistance rates in Afghanistan have shown a **rising trend over the past decade**, similar to trends observed in other **low- and middle-income countries (LMICs) [13, 18, 66]**.

- **2010–2015:** Resistance rates remained **below 50%** for most pathogens *[18, 28, 31,32,53]*.
- **2016–2020:** Resistance increased significantly, surpassing **60% for MRSA and 70% for Klebsiella pneumoniae** *[18, 28, 31,32,53]*.
- **2021–2024:** The latest estimates indicate resistance exceeding **80% for first-line antibiotics,** particularly among *E. coli* and *Klebsiella pneumoniae [18, 28, 31,32,53]*.

The rapid escalation in resistance correlates with **increased antibiotic misuse, self-medication, and lack of regulatory enforcement** in Afghanistan.

3. Geographic Distribution of Resistance Patterns

Resistance patterns in Afghanistan exhibit notable **regional variations**, influenced by **healthcare access, antibiotic misuse, and surveillance capabilities [33].**

- **Urban Centers (Kabul, Herat, Kandahar):**
  - Higher **hospital-acquired resistance**, particularly **MRSA (66%) and carbapenem-resistant** *Klebsiella pneumoniae* **(72%)** [18, 19, 20, 26, 27].
  - More frequent **multidrug-resistant (MDR) infections** due to antibiotic overuse in hospitals [18, 19, 20, 26, 27].
- **Rural Provinces (Helmand, Badakhshan, Herat):**
  - Greater reliance on **over-the-counter antibiotics**, leading to **high fluoroquinolone and beta-lactam resistance in** *E. coli* **(>75%)** [18, 19, 20, 26, 53].
  - **Limited diagnostic capabilities** result in **delayed detection** of resistant strains [18, 19, 20, 26, 53].

This regional disparity underscores the need for **customized AMR interventions** in urban and rural settings.

4. Hospital-Acquired vs. Community-Acquired Resistance

Resistance patterns also vary between **hospital settings (nosocomial infections) and community settings (self-medicated antibiotic use) (Table 3) [13 – 17, 24,25]:**

Table 3: *Hospital-Acquired vs. Community-Acquired Resistance Type*

Resistance Type	Hospital-Acquired (HA) Infections	Community-Acquired (CA) Infections
MRSA (Methicillin-resistant S. aureus)	66.3%	45.1%
Klebsiella pneumoniae **(Carbapenem-resistant)**	72.5%	50.2%
E. coli **(Fluoroquinolone-resistant)**	78.4%	62.1%
Acinetobacter baumannii **(Multidrug-resistant)**	58.0%	40.3%

- **Hospital-acquired AMR cases** tend to be more severe due to **inadequate infection control and excessive broad-spectrum antibiotic use [13 – 17, 24,25].**

- **Community-acquired resistance** is driven by **self-medication and unregulated pharmacy sales,** requiring **urgent public awareness campaigns [13 – 17, 24,25].**

4. Challenges in Tackling AMR in Afghanistan

Afghanistan faces numerous interwoven challenges in combating antimicrobial resistance (AMR). Decades of conflict, political instability, and economic hardship have weakened the country's healthcare infrastructure, severely limiting efforts to regulate antibiotic use and enforce infection prevention and control (IPC) measures. Compounding these challenges are inadequate sanitation, overcrowded healthcare facilities, a lack of trained healthcare personnel, and widespread misuse of antibiotics. Despite various interventions aimed at mitigating the AMR crisis, many have fallen short due to structural and resource limitations. Addressing these challenges requires a multi-faceted approach, but Afghanistan's limited resources make it difficult to establish effective AMR interventions [30-50, 64]. Table 4 provides an overview of Afghanistan's AMR-related policies, their objectives, and their current implementation status, highlighting key gaps that hinder effective AMR mitigation.

Table 4: AMR Policies, Plans, and Implementation Status in Afghanistan

Policy/Plan	Description	Implementation Status
Afghanistan National Action Plan (NAP) on AMR	A strategic plan developed in alignment with WHO guidelines to combat AMR through surveillance, stewardship, and public awareness.	Published, but implementation remains limited due to political instability and resource constraints.
National Drug Regulation Policy	Establishes guidelines for antibiotic prescriptions and sales to reduce over-the-counter antibiotic misuse.	Weak enforcement; many pharmacies continue to sell antibiotics without prescriptions.
AMR Surveillance Program	Aims to track resistance patterns in hospitals and communities to guide interventions.	Partially implemented in major cities (Kabul, Herat, Mazar-i-Sharif), but lacks national coverage.
Infection Prevention and Control (IPC) Guidelines	Focuses on hygiene, sanitation, and hospital-based AMR containment measures.	Adopted in select hospitals but underfunded and inconsistently applied.
Antimicrobial Stewardship Programs (ASPs)	Hospital-based initiatives to regulate antibiotic use and promote evidence-based prescriptions.	Piloted in a few tertiary hospitals; yet to be expanded to smaller healthcare facilities.

Regulation of Veterinary Antibiotic Use	Seeks to limit antibiotic use in livestock and prevent AMR transmission through the food chain.	Poorly enforced; antibiotics remain widely used for growth promotion in livestock.
Public Awareness Campaigns on AMR	Education campaigns by the Ministry of Public Health (MoPH) and WHO to inform the public about responsible antibiotic use.	Limited reach; mostly urban-focused, with little penetration into rural areas.

This table provides a structured overview of Afghanistan's current AMR policies, highlighting areas where implementation remains a challenge. Strengthening these efforts is critical to mitigating AMR in the country.

Healthcare Infrastructure and Infection Prevention and Control (IPC)

Afghanistan’s healthcare system is severely under-resourced, with significant deficiencies in infrastructure and IPC practices. Decades of war have left many healthcare facilities in ruins, and efforts to rebuild have been hampered by ongoing conflict. According to the World Health Organization (WHO), many hospitals and clinics in Afghanistan lack basic amenities such as running water, proper sanitation, and waste disposal systems [38, 44]. These conditions create ideal environments for the spread of drug-resistant infections.

Inadequate Healthcare Facilities and IPC Practices

A key challenge in Afghanistan’s fight against AMR is the inadequacy of healthcare facilities and IPC measures. Although IPC is critical in preventing the spread of infections, particularly in hospitals where patients are vulnerable to hospital-acquired infections, Afghan hospitals often lack the basic resources needed to implement effective IPC protocols. Shortages of personal protective equipment (PPE), sterilization tools, and other essential supplies make it difficult for healthcare workers to maintain hygiene standards [22, 24, 25, 38, 41, 42, 44, 45, 46, 48, 54]. Additionally, overcrowding in hospitals exacerbates the spread of infections. With limited hospital beds and healthcare providers, patients are often crammed into small, unhygienic spaces, further increasing the risk of drug-resistant infections spreading between patients.

Several interventions aimed at improving healthcare infrastructure and IPC practices have been implemented over the past decade. For instance, the Global Fund, in collaboration with the Afghan Ministry of Public Health (MoPH), launched programs to improve water, sanitation, and hygiene (WASH) facilities in hospitals and clinics (10, 54, 55). These programs have achieved some success in urban hospitals, particularly in Kabul and Kandahar, where upgrades to sanitation systems have reduced infection rates. However, the success of these programs has been limited to a few urban centers, and most rural healthcare facilities continue to operate without access to clean water or proper waste disposal systems [33-37].

Efforts to improve IPC training for healthcare workers have also seen mixed results. WHO and the United Nations Children's Fund (UNICEF) have conducted IPC training programs in several provinces, focusing on hand hygiene, the proper use of PPE, and sterilization techniques [39, 45]. While these programs have led to improved knowledge and practices among healthcare workers in the targeted regions, the lack of a nationwide IPC policy and enforcement mechanisms has prevented these practices from being widely adopted. As a result, many healthcare workers continue to operate without adequate training or supplies, particularly in rural and conflict-affected areas [24, 33].

Overcrowded and Understaffed Facilities

The issue of overcrowding in Afghan hospitals, particularly in Kabul, Kandahar, and other urban centers, remains a critical challenge. Overcrowding, combined with poor sanitation, creates environments where resistant infections spread easily. Afghan healthcare workers, who are already overwhelmed by large patient volumes, find it difficult to implement strict IPC protocols in such conditions. In particular, wards for immunocompromised patients, such as those with tuberculosis (TB) or multidrug-resistant infections, are often crowded and understaffed, leading to high rates of hospital-acquired infections [24, 41].

In response, several initiatives have aimed to alleviate overcrowding. For example, the MoPH, with support from international organizations, launched a program to decentralize healthcare services by building smaller healthcare centers in rural areas to reduce the burden on major hospitals. However, these efforts have been hindered by security challenges and a lack of qualified healthcare personnel to staff these new facilities. Consequently, many of these centers remain underutilized or non-functional, and overcrowding in urban hospitals persists [22, 44, 45].

Surveillance and Data Collection

One of the most critical challenges in Afghanistan's fight against AMR is the lack of a comprehensive national surveillance system to monitor resistance patterns. Surveillance is essential for understanding the scope of the AMR problem, identifying key pathogens, and developing effective strategies to combat resistance. However, Afghanistan's surveillance systems are fragmented and under-resourced, making it difficult to collect reliable data on AMR trends. This lack of reliable data hampers the country's ability to respond effectively to AMR. Despite Afghanistan's development of a National Action Plan (NAP) on AMR (Table 2), its implementation remains limited due to political and economic challenges, making antibiotic misuse a persistent issue.

Inadequate National Surveillance Systems

Efforts to establish a national-level AMR surveillance system have been limited in scope. The MoPH, in collaboration with the WHO, has attempted to implement surveillance programs for specific diseases, such as tuberculosis (TB) and HIV, with some success. However, these programs have not been expanded to include drug-resistant bacterial infections [22, 24, 25, 38, 41, 42, 44, 45, 46, 48, 54]. Furthermore, healthcare facilities in rural areas, where access to diagnostic tools is limited, often do not have the capacity to detect or report cases of AMR. Without a coordinated, national surveillance system, policymakers and healthcare providers lack the data needed to develop targeted interventions or allocate resources effectively.

Several international organizations, including the WHO and the United States Agency for International Development (USAID), have provided technical and financial support to improve Afghanistan's AMR surveillance capacity. For example, USAID funded the establishment of diagnostic laboratories in Kabul, Herat, and Mazar-i-Sharif, which are capable of identifying drug-resistant infections. However, the reach of these facilities is limited, and many rural regions remain without access to diagnostic services [34]. Additionally, the ongoing conflict and political instability have disrupted surveillance activities in several provinces, further complicating efforts to track AMR trends.

Economic Impact of Antimicrobial Resistance in Afghanistan

Antimicrobial resistance (AMR) presents a significant economic burden to Afghanistan's fragile healthcare system, leading to increased treatment costs, loss of productivity, and strain on healthcare infrastructure. Below is a detailed breakdown of its financial implications (Table 5).

Direct Healthcare Costs

AMR-related infections impose substantial treatment costs, particularly due to prolonged hospital stays, use of second- and third-line antibiotics, and increased mortality rates [64, 68, 69].

- The cost of treating multidrug-resistant (MDR) infections in low- and middle-income countries (LMICs) is estimated to be 2–6 times higher than treating non-resistant infections [64, 68, 69].

- In Afghanistan, the estimated hospital admission cost for an AMR-related infection is $350–$1,200, depending on disease severity and treatment setting [64, 68, 69].
- Resistant infections increase hospitalization time by 10–20 additional days, leading to overcrowded hospitals and resource depletion [64, 68, 69].
- The cost of last-resort antibiotics (e.g., carbapenems, colistin) is 3–5 times higher than first-line treatments, making them unaffordable for many Afghan patients [64, 68, 69].

Indirect Economic Burden

Beyond direct medical expenses, AMR significantly impacts the economy through productivity losses, premature deaths, and increased healthcare expenditures.

- Annual productivity losses due to AMR-related morbidity and mortality in Afghanistan are estimated at $200–$500 million [64, 68, 69].
- The country records an estimated 8,700 direct deaths and 34,300 deaths linked to resistant infections annually, reducing workforce availability and economic productivity [64, 68, 69].
- Over 60% of healthcare expenses in Afghanistan are out-of-pocket, pushing many families into financial hardship [64, 68, 69].

Resource Allocation for AMR Mitigation

To combat AMR, Afghanistan requires substantial investments in the following areas:

Table 5: Estimated Financial Investment Required for AMR Control in Afghanistan

Intervention	Estimated Cost
National AMR surveillance system	$10–$20 million over five years [64]
Rapid diagnostic tools (PCR, culture tests)	$2,000 per hospital per year [64]
Public awareness and stewardship programs	$5–$10 million [64]
Regulating antibiotic sales and hospital interventions	$3–$5 million for enforcement [64]
Hospital antimicrobial stewardship programs	$1 million per year for major cities [64]

Cost-Benefit Analysis:

- Studies indicate that every $1 invested in AMR prevention saves $5 in healthcare costs [68].
- Implementing effective AMR containment policies could save over $100 million annually in Afghanistan [64] .

Addressing AMR in Afghanistan requires urgent and strategic investments in surveillance, regulation, and stewardship. While initial costs may seem high, failing to act will escalate healthcare expenditures, increase mortality, and weaken the national economy. A long-term, sustainable plan will help mitigate AMR risks and protect public health.

Challenges in Collecting Reliable Data

Collecting reliable AMR data in remote and conflict-affected regions is particularly challenging. Healthcare facilities in these areas are often inaccessible, and security concerns prevent healthcare workers from conducting surveillance activities. The lack of infrastructure, including diagnostic laboratories and communication networks, means that many cases of AMR go undiagnosed or unreported [24, 45, 46]. As a result, Afghanistan lacks a clear picture of how AMR is spreading in different regions, particularly in rural and conflict-affected areas.

Despite these challenges, some progress has been made in specific regions. In 2019, the MoPH, with support from international partners, launched the National Health Information System (NHIS), which aims to improve data collection across all healthcare sectors. While the NHIS has improved data reporting in urban hospitals, its implementation in rural areas has been slow, and its effectiveness in tracking AMR remains limited [33, 37].

Antibiotic Misuse

The misuse of antibiotics is one of the primary drivers of AMR in Afghanistan. High rates of self-medication, over-the-counter antibiotic sales, and cultural misconceptions about antibiotics contribute to widespread misuse [25]. Regulatory frameworks intended to control the sale of antibiotics are poorly enforced, and public education campaigns have been insufficient in raising awareness about the dangers of antibiotic mismanagement.

High Rates of Self-Medication and Over-the-Counter Sales

In Afghanistan, antibiotics are widely available over-the-counter without any prescription or medical guidance. Pharmacies, particularly in rural and underserved areas, frequently sell antibiotics to customers who may not understand the importance of proper antibiotic use. Efforts to regulate over-the-counter sales of antibiotics have been implemented by the MoPH, but enforcement remains weak. Pharmacies often operate with little oversight, and many continue to sell antibiotics without requiring a prescription [22, 38, 44, 48].

A public education campaign on unnecessary antibiotic use was launched by the MoPH and the WHO in 2018, which aimed to raise awareness about the risks of self-medication and incomplete antibiotic courses. While the campaign was successful in increasing awareness among healthcare workers, its reach among the general population, particularly in rural areas, has been limited [61, 61]. As a result, self-medication with antibiotics remains widespread, further fueling the development of resistant infections [35].

Impact of COVID-19 on AMR in Afghanistan

The COVID-19 pandemic exacerbated existing healthcare challenges in Afghanistan and increased the risks associated with AMR. Healthcare facilities, already overstretched, were overwhelmed by the sudden influx of COVID-19 patients, diverting resources away from AMR surveillance and infection control efforts. Many hospitals, which were already suffering from overcrowding and poor sanitation, became hotspots for the transmission of resistant infections [22, 24, 25, 38, 41, 42, 44, 45, 46, 48].

Strained Resources and Healthcare Challenges

The COVID-19 pandemic strained Afghanistan's healthcare system, making it difficult to maintain IPC measures. Shortages of personal protective equipment (PPE) and other essential medical supplies, compounded by overcrowded wards, created environments where drug-resistant infections could spread rapidly. Healthcare workers, already overwhelmed by the demands of the pandemic, had little capacity to implement IPC protocols or track AMR cases [24, 45, 46]. The pandemic also disrupted routine healthcare services, including AMR surveillance programs. Many healthcare facilities shifted their focus to managing COVID-19 cases, leaving little capacity for tracking drug-resistant infections [22, 38].

5. Factors Contributing to AMR in Afghanistan

Afghanistan's antimicrobial resistance (AMR) crisis is driven by a combination of factors that span the healthcare, agricultural, and public health sectors. The widespread overuse and misuse of antibiotics in both human and animal health, economic barriers, lack of public awareness, and unregulated pharmaceutical markets have created an environment where AMR can thrive. These factors are intertwined with the country's socio-economic conditions, making it increasingly difficult to control the spread of drug-resistant pathogens. Understanding these factors is essential for developing comprehensive strategies to combat AMR in Afghanistan.

Overuse and Misuse of Antibiotics in Human and Animal Health

One of the primary contributors to AMR in Afghanistan is the overuse and misuse of antibiotics in both human medicine and veterinary practice. Antibiotics are often prescribed or consumed inappropriately, leading to the development of resistant bacteria that can no longer be treated with standard drugs. This misuse occurs at multiple levels of the healthcare system, as well as in the agricultural sector.

Inappropriate Use in Human Health

In human healthcare, antibiotics are frequently used as a first-line treatment for illnesses that may not require them. This includes viral infections such as the common cold and flu, for which antibiotics are ineffective. Despite this, many healthcare providers prescribe antibiotics without properly diagnosing whether the infection is bacterial or viral [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54]. In rural areas where diagnostic tools are scarce, physicians often prescribe antibiotics as a precautionary measure, even when they are not necessary [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54].

Self-medication with antibiotics is another critical issue. In Afghanistan, a large portion of the population engages in self-medication, often using antibiotics to treat minor ailments without consulting a healthcare professional. This practice is particularly prevalent in regions with limited access to healthcare facilities, where people rely on pharmacies or informal healthcare providers for treatment [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54]. Antibiotics are often taken at incorrect dosages or for incomplete courses, allowing bacteria to survive and develop resistance.

The lack of regulation around the sale of antibiotics exacerbates the problem. Over-the-counter sales of antibiotics are common, and many people purchase these drugs without a prescription [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54]. This unrestricted access to antibiotics has led to their overuse, further driving the emergence of resistant strains.

Misuse in Animal Health

The misuse of antibiotics is not confined to human medicine; it is also widespread in Afghanistan's agricultural sector. Antibiotics are frequently used in livestock farming to prevent diseases and promote growth, rather than to treat infections [7, 63-65]. This practice is particularly common in poultry and cattle farming, where antibiotics are often administered routinely, even in healthy animals. The use of antibiotics as growth promoters in livestock accelerates the development of resistant bacteria, which can then be transmitted to humans through direct contact with animals or through the consumption of animal products [7, 63-65].

In Afghanistan, many farmers lack proper veterinary services and often administer antibiotics without professional guidance. As in human health, the incorrect use of antibiotics in animals, including the failure to complete prescribed treatment courses, allows resistant bacteria to proliferate. This issue is further compounded by the lack of public awareness about the risks associated with antibiotic use in agriculture.

The spread of resistant bacteria from animals to humans through the food chain is a growing concern. Resistant bacteria can survive on meat and other animal products, and improper food handling or insufficient cooking can result in human infection. Additionally, antibiotic residues in animal products can contribute to resistance in human pathogens [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54].

Economic Barriers Leading to Self-Medication and Improper Use of Antibiotics

Afghanistan's fragile economy plays a significant role in the misuse of antibiotics. The country's healthcare system is underfunded, and many people, especially in rural areas, cannot afford to seek professional medical care. As a result, self-medication with antibiotics becomes a more attractive option for treating common ailments.

Cost Barriers to Healthcare Access

Economic hardship forces many Afghans to rely on self-medication as a cost-saving measure. Consulting a healthcare professional often comes with out-of-pocket expenses that many cannot afford, leading individuals to purchase antibiotics directly from pharmacies without a prescription [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54]. This practice is particularly common in rural areas where medical services are limited and expensive.

In addition, healthcare providers may prescribe cheaper antibiotics as a first-line treatment, even in cases where more effective, albeit more expensive, drugs are required. This compromises the effectiveness of treatment, particularly in patients with resistant infections [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54]. As a result, people may not complete their prescribed antibiotic course, either due to financial constraints or because they believe their symptoms have improved. This improper use of antibiotics contributes to the development of resistance, as incomplete courses fail to eliminate all the bacteria, allowing the surviving ones to adapt.

Lack of Access to Quality Medicines

Afghanistan's economic challenges also limit the availability of quality medicines. Substandard and counterfeit antibiotics are common in the country's unregulated pharmaceutical market. These low-quality drugs are often less effective, leading to incomplete treatment and the continued survival of resistant bacteria [64, 66, 67]. Moreover, substandard antibiotics may not reach the required therapeutic levels in the body, providing an environment where bacteria can develop resistance.

Lack of Public Awareness and Education Regarding AMR

The lack of public awareness about antimicrobial resistance is a critical barrier to addressing the AMR crisis in Afghanistan. Many people in the country, particularly in rural areas, are unaware of the risks associated with improper antibiotic use. This lack of knowledge leads to widespread misuse of antibiotics, both in human and animal health [19, 25].

Public Misconceptions About Antibiotics

Public misconceptions about antibiotics are widespread in Afghanistan. Many people believe that antibiotics are a cure-all for any type of illness, including viral infections like the common cold and flu. This misconception is reinforced by the ease with which antibiotics can be purchased without a prescription, leading individuals to use these drugs indiscriminately [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54].

In rural areas, where healthcare services are limited, people often view antibiotics as the first line of defense against any illness, regardless of the cause. This overreliance on antibiotics not only increases the risk of resistance but also contributes to the spread of misinformation about their proper use [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54]. Without public education campaigns to dispel these misconceptions, the cycle of misuse is likely to continue.

Limited Public Health Campaigns

Despite the growing threat of AMR, public health campaigns aimed at raising awareness about the risks of excessive antibiotic consumption are limited in Afghanistan. The Ministry of Public Health (MoPH) and international organizations have made efforts to educate the public about the dangers of self-medication and overuse of antibiotics, but these campaigns have not reached all areas, particularly remote regions where irresponsible antibiotic practices is most common [8, 9, 10, 64, 67]. The lack of widespread educational initiatives leaves many people uninformed about the proper use of antibiotics and the consequences of resistance.

Furthermore, healthcare workers themselves may lack adequate knowledge about AMR and the correct prescription practices for antibiotics. Without proper training, healthcare providers may continue to contribute to the problem by over-prescribing antibiotics or failing to educate patients on the importance of completing their treatment courses [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54].

Unregulated Pharmaceutical Markets and Easy Availability of Antibiotics

Afghanistan's unregulated pharmaceutical market is one of the primary drivers of antibiotic mismanagement. In many parts of the country, antibiotics are readily available for purchase without a prescription, making it easy for people to access and misuse these drugs.

Over-the-Counter Sales of Antibiotics

The lack of regulatory oversight allows pharmacies to sell antibiotics over the counter without requiring a prescription. This widespread availability of antibiotics contributes to their misuse, as individuals often purchase and use these drugs without proper medical guidance [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54]. Pharmacies in rural and underserved areas are particularly likely to engage in this practice, as there are few regulations in place to prevent it.

In addition to selling antibiotics without prescriptions, pharmacies may also provide incorrect advice about the use of these drugs. Many pharmacists are not trained in antimicrobial stewardship and may recommend antibiotics for conditions that do not require them, such as viral infections [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54]. This lack of regulation and education among pharmacists further contributes to the spread of AMR.

Counterfeit and Substandard Medications

The proliferation of counterfeit and substandard medications in Afghanistan's pharmaceutical market further complicates the AMR problem. These drugs often contain incorrect dosages or ineffective ingredients, leading to incomplete treatment and allowing resistant bacteria to thrive [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54]. The absence of stringent quality control measures in the pharmaceutical supply chain makes it difficult to ensure that antibiotics sold in the market are of high quality, which is essential for combating resistance.

Without stronger regulatory frameworks and enforcement mechanisms, the unregulated sale of antibiotics will continue to fuel the rise of AMR in Afghanistan. Addressing this issue requires not only stricter laws but also improved surveillance and monitoring of pharmaceutical sales across the country.

6. Strategic Responses to Combat AMR

Addressing antimicrobial resistance (AMR) in Afghanistan requires a multifaceted approach that includes regulatory reforms, improved healthcare practices, better diagnostic capabilities, and comprehensive public education campaigns. Given the country's unique challenges—political instability, a fragile healthcare system, and widespread antibiotic overuse or misuse—tailored strategies are essential for combating AMR effectively. This section outlines key strategic responses to tackle AMR in Afghanistan, focusing on strengthening regulations, enhancing surveillance, improving diagnostics, raising public awareness, and fostering transnational cooperation.

Regulation of Antibiotic Sales

One of the primary drivers of AMR in Afghanistan is the unregulated sale and misuse of antibiotics. Pharmacies often sell antibiotics over the counter without requiring a prescription, making it easy for individuals to purchase and use these drugs indiscriminately [33]. Stricter control of antibiotic sales and improved prescription practices are critical for reducing misapplication of antibiotics.

Stricter Control of Over-the-Counter Sales

To curb the overuse of antibiotics, Afghanistan needs to implement and enforce stricter regulations on the sale of these drugs. A key step is to prohibit over-the-counter sales of antibiotics without a prescription. This would require pharmacies to verify prescriptions before dispensing antibiotics, ensuring that they are only used under proper medical supervision [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54]. However, given the weak regulatory framework in Afghanistan, this will require significant investment in regulatory bodies and the training of pharmacists and healthcare workers.

The government can also adopt stricter penalties for pharmacies that violate these regulations. Implementing a system of monitoring and penalties for non-compliance can discourage illegal sales and contribute to more responsible use of antibiotics [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54]. Furthermore, efforts should be made to reduce the availability of counterfeit antibiotics, which contribute to incomplete treatments and resistance. Strengthening supply chain oversight and introducing quality control measures are essential to ensure that antibiotics sold in the country are safe and effective.

Improved Prescription Practices

In addition to regulating over-the-counter sales, healthcare providers must adopt better prescription practices. This can be achieved through the implementation of antimicrobial stewardship programs (ASPs) in healthcare facilities. ASPs are designed to ensure that antibiotics are prescribed only when necessary and in the correct dosage and duration. These programs should be integrated into both public and private healthcare systems across the country[22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54].

Training healthcare providers to follow evidence-based guidelines when prescribing antibiotics is essential. Workshops and continuing medical education (CME) programs on antibiotic use, stewardship, and the risks of AMR can improve healthcare providers' awareness and reduce inappropriate prescribing [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54]. Additionally, healthcare facilities should be encouraged to establish antibiotic prescribing committees to review prescriptions and ensure compliance with stewardship protocols.

Strengthening AMR Surveillance

A robust AMR surveillance system is crucial for tracking resistance patterns and guiding public health interventions. Afghanistan currently lacks a comprehensive national surveillance system to monitor the prevalence and spread of drug-resistant infections across the country. Establishing such a system would allow healthcare authorities to collect and analyze data on AMR trends, identify high-risk areas, and tailor interventions accordingly.

Establishment of a National AMR Surveillance System

The Ministry of Public Health (MoPH) should prioritize the development of a national AMR surveillance system that collects data from healthcare facilities, laboratories, and pharmacies across the country. This system should be designed to monitor resistance patterns in both hospital-acquired and community-acquired infections, ensuring that healthcare authorities have a clear understanding of how resistance is spreading [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54].

Surveillance should be extended to both rural and urban areas, as AMR can vary significantly depending on healthcare access, population density, and local antibiotic use. A province-based approach would allow regional health authorities to track AMR trends in their specific areas, identify hotspots for resistance, and implement targeted interventions [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54]. Moreover, data collection should include information on antibiotic prescriptions, patient outcomes, and pathogen susceptibility patterns, allowing for a comprehensive analysis of AMR trends.

To support this initiative, the government should invest in laboratory infrastructure and the training of healthcare workers in diagnostic and data collection techniques. The establishment of reference laboratories in major cities like Kabul, Kandahar, and Herat would enhance the country's ability to detect resistant pathogens and share data with global health organizations [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54].

Improving Diagnostics

The widespread misuse of antibiotics in Afghanistan is partly due to the lack of diagnostic tools that can differentiate between bacterial and viral infections. Without proper diagnostics, healthcare providers often prescribe antibiotics as a precautionary measure, even when they are not needed. Expanding the availability of point-of-care diagnostic tools is essential to reducing unnecessary antibiotic prescriptions.

Expansion of Point-of-Care Diagnostic Tools

Point-of-care diagnostic tools, such as C-reactive protein (CRP) tests, can help healthcare providers determine whether a patient's infection is bacterial or viral. By using these tests in clinics and hospitals, healthcare providers can make more informed decisions about whether antibiotics are necessary [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54]. The availability of rapid diagnostic tools would significantly reduce the misuse of antibiotics for viral infections and limit the spread of resistant bacteria.

To implement this strategy, the government should invest in expanding diagnostic services, particularly in rural and underserved areas where access to healthcare is limited. Training healthcare workers on the use of point-of-care tests and interpreting the results will also be crucial to ensure that these tools are used effectively [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54].

In addition, expanding diagnostic capabilities in hospitals and clinics will enable healthcare providers to identify resistant pathogens more accurately and prescribe the appropriate treatment. Investing in diagnostic laboratories, particularly in major cities and conflict-affected regions, will help improve the detection and monitoring of AMR [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54].

Public Awareness Campaigns

Public education is a key component in the fight against AMR. Misconceptions about antibiotic use and self-medication are widespread in Afghanistan, contributing to the misuse of these drugs. Effective public awareness campaigns can help change behaviors and promote responsible antibiotic use among the general population, healthcare workers, and farmers.

Focused Educational Initiatives

Community outreach programs should be designed to target key groups, including healthcare providers, pharmacists, farmers, and the general public. These campaigns should focus on the dangers of unnecessary antibiotic use, the importance of completing prescribed antibiotic courses, and the distinction between bacterial and viral infections [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54]. Educational materials should be culturally appropriate and available in local languages to ensure they reach a wide audience.

Healthcare providers and pharmacists should receive specific training on the principles of antimicrobial stewardship, proper prescribing practices, and the risks of AMR. Farmers and livestock producers should also be educated on the responsible use of antibiotics in animal husbandry to reduce the misuse of antibiotics in agriculture [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54]. Workshops, seminars, and community outreach programs can help raise awareness in rural and urban areas alike.

Role of Local Leaders and Community Influencers

Local leaders and community influencers play a crucial role in spreading awareness about AMR, particularly in rural and conservative regions of Afghanistan. Religious leaders, elders, and other respected figures within communities can help reinforce public health messages and encourage responsible antibiotic use [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54]. Partnering with these influencers will help ensure that AMR awareness campaigns resonate with the local population and lead to lasting behavioral changes.

Community health workers can also be mobilized to engage with households and educate families on the proper use of antibiotics, helping to reduce self-medication and over-the-counter antibiotic purchases [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54].

International Collaboration

Given Afghanistan's limited resources and capacity to tackle AMR independently, worldwide teamwork is essential. Partnering with global organizations like the World Health Organization (WHO), the Fleming Fund, and other international donors can provide financial and technical support to strengthen the country’s response to AMR.

Partnering with Global Organizations

International organizations such as the WHO and the Fleming Fund can play a key role in supporting Afghanistan’s AMR initiatives by providing technical expertise, funding, and resources for surveillance, diagnostics, and public health campaigns [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54]. These organizations can also assist in building laboratory capacity, training healthcare workers, and establishing AMR surveillance systems across the country.

Collaborating with regional bodies and neighboring countries, such as Pakistan and Iran, can also help Afghanistan address cross-border issues related to AMR. Given the movement of people and goods across borders, regional collaboration on AMR surveillance and control measures is critical to preventing the spread of resistant pathogens across the region [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54].

Financial and Technical Support

International donors can provide much-needed financial support for Afghanistan's AMR response. This includes funding for infrastructure development, such as building diagnostic laboratories, equipping hospitals with diagnostic tools, and training healthcare professionals [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48, 54]. Additionally, technical assistance from international experts can help Afghanistan develop and implement national AMR action plans, improve antibiotic regulation, and promote antimicrobial stewardship [33-37].

Sustained international support will be crucial in ensuring that Afghanistan's AMR response is effective and sustainable in the long term.

7. Case Studies and Lessons from Other LMICs

Afghanistan, like other low- and middle-income countries (LMICs), faces significant challenges in addressing antimicrobial resistance (AMR). However, valuable lessons can be drawn from the experiences of Ethiopia, India, and Malaysia, which have implemented successful strategies to curb inappropriate use of antibiotics, improve healthcare practices, and reduce the burden of AMR. This section explores these case studies and highlights how Afghanistan can realistically implement similar interventions, taking into account the country's ongoing political and infrastructural challenges.

Case Study 1: Pneumococcal Vaccination in Ethiopia

The Role of Vaccination in Reducing Antibiotic Use and AMR

In Ethiopia, the introduction of pneumococcal conjugate vaccines (PCVs) has significantly reduced the need for antibiotics by preventing infections such as pneumonia, meningitis, and sepsis in children—conditions that often lead to unnecessary antibiotic prescriptions. By reducing the incidence of pneumococcal infections through vaccination, Ethiopia has lowered the demand for antibiotics and helped slow the spread of AMR [21, 49]. The PCV program, introduced in 2011, has been particularly effective among children under five, significantly reducing hospitalizations and antibiotic use for respiratory infections [21, 49].

Relevance to Afghanistan's Context

Vaccination can play a similarly vital role in Afghanistan, where preventable bacterial infections, particularly in children, contribute to high rates of improper antibiotic usage. Expanding immunization programs in Afghanistan, particularly for diseases like pneumonia and meningitis, would decrease the incidence of bacterial infections and reduce reliance on antibiotics. This approach is feasible even in the current political climate, as vaccination programs are often supported by international organizations such as UNICEF and the Global Alliance for Vaccines and Immunization (GAVI), which have successfully operated in conflict-affected regions.

Proposed Implementation for Afghanistan

1. **Short-term (1–2 years):** Afghanistan should prioritize expanding its existing vaccination programs, particularly for children, by collaborating with international organizations that can provide technical support and funding. Given the challenging political environment, vaccination efforts should focus first on relatively stable urban areas and regions with secure healthcare access.

2. **Medium-term (2–5 years):** As the security situation allows, vaccination programs should be extended to rural and conflict-affected areas. International donors and healthcare partners can help deploy mobile vaccination teams to ensure that children in remote regions are reached. By preventing infections at the community level, Afghanistan can make significant strides in reducing the need for antibiotics in these high-risk populations.

3. **Long-term (5+ years):** Sustained support for immunization programs should be integrated into Afghanistan's national healthcare strategy, with ongoing financial and logistical backing from global donors. Vaccination rates should be regularly monitored, and data should be incorporated into AMR surveillance efforts to track the impact on antibiotic use.

Case Study 2: Antimicrobial Stewardship in India

The Impact of Antimicrobial Stewardship Programs (ASPs) on Reducing Antibiotic Misuse

India, one of the world's largest consumers of antibiotics, has made significant progress in reducing inappropriate antibiotic use through the implementation of antimicrobial stewardship programs (ASPs). ASPs are multidisciplinary initiatives that promote the appropriate use of antibiotics, focusing on evidence-based prescribing and monitoring antibiotic use in hospitals [52-60]. A study in Indian hospitals demonstrated a 25% reduction in the use of broad-spectrum antibiotics, such as third-generation cephalosporins and carbapenems, after ASP implementation [52-60]. This reduction led to fewer cases of hospital-acquired infections and better patient outcomes.

Relevance to Afghanistan's Context

Afghanistan, like India, faces widespread overprescription of antibiotics, particularly in hospital settings where resistant infections are most likely to spread. Implementing ASPs in major Afghan hospitals could help reduce inappropriate antibiotic use, improve patient outcomes, and slow the development of resistance. However, Afghanistan's healthcare system lacks many of the structural supports found in India, such as a large pool of trained healthcare professionals and established national guidelines for antimicrobial use.

Proposed Implementation for Afghanistan

1. **Short-term (1–2 years):** Afghanistan should initiate antimicrobial stewardship programs in tertiary hospitals located in relatively stable urban centers, such as Kabul, Herat, and Mazar-i-Sharif. These initial efforts can be supported by international partners, such as WHO and USAID, which have experience in setting up ASPs in LMICs. The first step should be to train multidisciplinary teams of healthcare professionals, including infectious disease specialists and pharmacists, to review and monitor antibiotic prescriptions.

2. **Medium-term (2–5 years):** Once ASPs are established in urban hospitals, the focus should shift to expanding these programs to smaller hospitals and clinics in rural areas. Training for healthcare providers in rural settings is critical, and efforts should be made to integrate ASP principles into the curricula of medical and nursing schools across the country. Engaging local health authorities and traditional practitioners in stewardship efforts will also be important to ensure broad adoption of best practices.

3. **Long-term (5+ years):** Over the long term, Afghanistan should aim to institutionalize ASPs in its national healthcare system, with standardized antibiotic prescription guidelines and regular audits of antibiotic use in healthcare facilities. International partnerships and continued donor support will be critical for sustaining these efforts, especially in rural and conflict-affected areas where resources remain scarce.

Case Study 3: Educational Campaign in Malaysia

The Role of Public Education in Combating Antibiotic Misuse

Malaysia has effectively raised public awareness about the dangers of irresponsible antibiotic practices through a nationwide educational campaign called “Know Your Antibiotics.” This campaign, launched by the Ministry of Health, used multiple platforms—television, radio, social media, and community outreach—to educate the public about the risks of self-medication and overuse of antibiotics [52-60]. The campaign also targeted healthcare providers, encouraging them to educate patients about the importance of responsible antibiotic use. Surveys conducted after the campaign showed a significant increase in public awareness and a decrease in requests for antibiotics for viral infections like the common cold [52-60].

Relevance to Afghanistan’s Context

Afghanistan faces a similar challenge with widespread antibiotic mismanagement, driven by cultural misconceptions about the effectiveness of antibiotics for viral infections and a lack of public health education. Implementing a national educational campaign in Afghanistan could help shift public attitudes toward antibiotics and reduce the demand for unnecessary prescriptions. However, Afghanistan’s literacy levels and access to mass communication platforms are much lower than in Malaysia, particularly in rural areas.

Proposed Implementation for Afghanistan

1. **Short-term (1–2 years):** Afghanistan should launch a targeted public education campaign focused on urban centers where access to mass media is higher. This campaign could be modeled on Malaysia’s approach but adapted to the Afghan context, using radio and mobile messaging platforms to disseminate information about antibiotic overuse or misuse. The campaign should also involve local influencers, such as religious leaders, community health workers, and local councils, to ensure that the message reaches diverse audiences.

2. **Medium-term (2–5 years):** Once the campaign is established in urban areas, the government should expand it to rural regions through community-based outreach programs. Working with local leaders and leveraging existing health infrastructure, the campaign can be tailored to address specific cultural misconceptions about antibiotics that are prevalent in rural areas. International donors, such as the World Bank or the Global Health Security Agenda, can support these efforts by providing technical and financial resources.

3. **Long-term (5+ years):** In the long-term, Afghanistan should aim to integrate public health education on antibiotics into its national school curriculum, ensuring that future generations understand the importance of responsible antibiotic use. Public health messaging should also be integrated into the country’s broader health communications strategy, with ongoing campaigns targeting new health risks as they emerge.

Lessons for Afghanistan

These case studies offer valuable insights into how Afghanistan can adapt strategies from other LMICs to combat AMR:

1. **Vaccination Programs (Ethiopia):** Expanding immunization coverage can help prevent bacterial infections and reduce the need for antibiotics. By prioritizing vaccination programs, especially for children, Afghanistan can decrease the incidence of preventable infections and lessen reliance on antibiotics. Collaboration with international organizations is essential for expanding these programs, particularly in conflict-affected areas.

2. **Antimicrobial Stewardship (India):** Structured antimicrobial stewardship programs in hospitals are key to reducing inappropriate antibiotic use. Afghanistan should implement ASPs in its major hospitals and gradually expand them to rural healthcare centers. Training healthcare professionals and establishing monitoring systems for antibiotic prescriptions are crucial steps.

3. **Public Education (Malaysia):** Public education campaigns are essential for reducing antibiotic overuse or misuse. Afghanistan should develop a nationwide campaign, leveraging local influencers and media channels, to educate the public on the proper use of antibiotics. Tailoring the campaign for rural and urban contexts is critical for ensuring broad participation.

By learning from these case studies and adapting their strategies to Afghanistan's unique socio-political context, the country can develop targeted solutions to address AMR, protect the effectiveness of antibiotics, and improve overall public health.

8. Challenges for Healthcare Workers in Afghanistan

Healthcare workers in Afghanistan face numerous challenges that hinder their ability to combat antimicrobial resistance (AMR) and provide adequate healthcare to the population. These challenges have been exacerbated by years of conflict, political instability, and economic hardship, culminating in significant risks to their personal safety, mental health, and professional well-being. The COVID-19 pandemic has further strained the healthcare system, leading to difficulties in vaccine distribution and public mistrust of healthcare services. Addressing these challenges is essential to strengthening Afghanistan's healthcare system and its ability to respond to the AMR crisis [38-44].

Security and Mental Health Issues

Afghanistan's volatile security situation, particularly following the Taliban takeover in 2021, has created an environment of uncertainty and danger for healthcare workers. Attacks on healthcare facilities, targeted violence against medical personnel, and the broader security risks associated with working in conflict zones have left many healthcare workers vulnerable. These risks, coupled with the psychological toll of overwork and low wages, have contributed to a mental health crisis among healthcare providers [41, 46, 48].

Threats Faced by Healthcare Workers, Especially Post-Taliban Takeover

Healthcare workers in Afghanistan have long been targeted by insurgent groups, but the situation has worsened since the Taliban regained control of the country. Medical facilities, particularly those providing services to women and children, have been attacked or destroyed, leaving healthcare workers in constant fear for their safety [25, 44,53]. Reports indicate that several healthcare workers have been killed or abducted while carrying out their duties, particularly in conflict-affected regions. This has made it difficult to maintain consistent healthcare services in many areas, further limiting access to care for the population [22, 24, 25, 53].

Additionally, the political transition has led to a mass exodus of healthcare professionals from the country. Many doctors, nurses, and other healthcare workers have fled to neighboring countries or further abroad, seeking safety and stability. This brain drain has severely impacted Afghanistan's healthcare capacity, leaving those who remain with overwhelming workloads and limited support [22, 24, 25, 53].

The situation is particularly dire for female healthcare workers, who face additional challenges under Taliban rule. Restrictions on women's education and employment have curtailed the ability of female healthcare providers to work freely, limiting their access to patients and restricting the delivery of essential services, especially for women and children [22, 24, 25,41, 42,45, 46, 48 53]. These restrictions have significantly undermined the healthcare workforce, which already suffers from severe shortages.

Mental Health Challenges Due to Overwork, Low Wages, and Security Risks

The mental health of healthcare workers in Afghanistan is a growing concern, as many are suffering from burnout, anxiety, and depression due to the extreme demands placed on them. The country's ongoing conflict and political instability have resulted in a healthcare system that is understaffed, underfunded, and ill-equipped to handle the rising number of patients, particularly those with resistant infections [22, 24, 25,41, 42,45, 46, 48 53].

Healthcare workers are often required to work long hours in dangerous conditions, with limited access to medical supplies and personal protective equipment (PPE). These factors contribute to high levels of stress, which are compounded by low wages and, in some cases, months of unpaid salaries [22, 24, 25,41, 42,45, 46, 48 53]. The psychological toll of working under such conditions, combined with the constant threat of violence, has led to widespread mental health issues among healthcare workers.

Mental health support for healthcare professionals is severely lacking in Afghanistan. Few resources are available to help healthcare workers cope with the emotional and psychological strains of their jobs, and there are limited mental health services available even within the broader healthcare system [22, 24, 25, 38, 41, 42, 44 ,45, 46, 48 53]. Without targeted interventions to address these mental health challenges, the healthcare workforce will continue to deteriorate, further hindering efforts to combat AMR and other public health issues.

9. Recommendations for Future AMR Management

Afghanistan's fight against antimicrobial resistance (AMR) requires a comprehensive, phased approach addressing both immediate and long-term challenges. The following recommendations outline key strategies, with timelines for phased implementation, to develop a robust response to AMR. These strategies aim to strengthen Afghanistan's healthcare system, improve surveillance, enforce regulations, and secure international support. By implementing these recommendations over short-term, medium-term, and long-term phases, Afghanistan can address critical gaps and reduce the burden of drug-resistant infections [22, 24, 25, 38, 41, 42, 44, 45, 46, 48, 54].

Surveillance and Data Collection

Phase 1: Establishment of Basic AMR Surveillance (Short-term: 1–2 years)

Developing a robust national AMR surveillance system is crucial for understanding the extent of resistance in Afghanistan and guiding public health interventions. The first step should be the creation of a national surveillance framework that collects data from key healthcare facilities, laboratories, and pharmacies across major urban areas such as Kabul, Herat, and Kandahar. This system should focus on both hospital-acquired and community-acquired infections to provide a clearer picture of AMR in the country [22, 24, 25, 38, 41, 42, 44, 45, 57, 58].

To support this phase, the Ministry of Public Health (MoPH) should partner with international organizations, such as the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF), to secure technical expertise and funding. Initial investments should focus on expanding laboratory capacity in urban hospitals to ensure reliable diagnostic data [33, 35].

Phase 2: Expansion to Rural Areas and Integration into National Health Systems (Medium-term: 2–5 years)

Once urban centers have established basic AMR surveillance, the system should be expanded to include rural regions where healthcare infrastructure is less developed. This phase will require significant investments in healthcare infrastructure and training for healthcare workers in remote areas. The goal will be to create a comprehensive, nationwide AMR surveillance system that tracks resistance patterns across all regions.

In this phase, the surveillance system should also be integrated into Afghanistan's broader health information systems to enable real-time monitoring of resistance patterns, which will facilitate more timely public health responses [38, 44]. By the end of this phase, all provinces should have at least one diagnostic laboratory capable of tracking AMR.

Phase 3: Regular Reporting and Global Data Sharing (Long-term: 5+ years)

In the long-term, Afghanistan should establish mechanisms for regular AMR data reporting, both nationally and internationally. This will allow the MoPH to generate annual reports on AMR trends and share data with global health organizations, facilitating International joint efforts on combating AMR. Regional partnerships with neighboring countries (such as Pakistan and Iran) should also be prioritized to manage cross-border AMR threats [38, 44, 46].

Healthcare Infrastructure Improvements

Phase 1: Immediate Upgrades to Critical Facilities (Short-term: 1–2 years)

Addressing gaps in healthcare infrastructure is essential for managing drug-resistant infections. In the short-term, the MoPH should prioritize upgrading key hospitals and clinics in Kabul, Kandahar, and Herat to improve sanitation, access to clean water, and waste disposal systems. These upgrades will reduce the risk of hospital-acquired infections and improve patient outcomes [38, 44].

Healthcare workers should receive immediate training in infection prevention and control (IPC) practices, including hand hygiene, sterilization techniques, and the proper use of personal protective equipment (PPE). This training can be conducted with support from international organizations like WHO and USAID, which have previously provided IPC guidance to other conflict-affected countries [22, 24, 25].

Phase 2: Expansion to Secondary Hospitals and Rural Clinics (Medium-term: 2–5 years)

In the medium term, the focus should shift to expanding healthcare infrastructure upgrades to secondary hospitals and rural clinics, ensuring that all healthcare facilities meet minimum IPC standards. A phased approach can be adopted, with each province receiving targeted investments based on population size and healthcare needs.

Expanding IPC training programs to healthcare workers in rural areas is also critical during this phase. Rural healthcare centers are often under-resourced, and healthcare workers in these areas must receive additional support and resources to maintain IPC practices [33, 38].

Phase 3: Strengthening the Healthcare Workforce and Digital Health Solutions (Long-term: 5+ years)

In the long-term, Afghanistan should focus on strengthening its healthcare workforce through education and recruitment programs. Scholarships and training initiatives aimed at increasing the number of trained healthcare professionals, particularly in rural areas, should be implemented. These programs should focus on training new generations of doctors, nurses, and IPC specialists.

In addition, Afghanistan should invest in digital health solutions to support healthcare delivery in remote regions. Telemedicine platforms can help rural healthcare workers access expert guidance on IPC and AMR management, enabling a more equitable healthcare system across the country [38, 44].

Regulatory and Policy Interventions

Phase 1: Immediate Enforcement of Antibiotic Sales Regulations (Short-term: 1–2 years)

The unregulated sale and misuse of antibiotics are major drivers of AMR in Afghanistan. In the short term, Afghanistan must implement and strictly enforce regulations that prohibit the sale of antibiotics without a prescription. Pharmacies should be required to adhere to legal requirements for dispensing antibiotics, and penalties should be introduced for non-compliance [38, 44, 60].

This phase can be supported by an initial public awareness campaign aimed at educating both pharmacists and the public on the dangers of improper antibiotic usage. International partners, such as the Fleming Fund, can assist in providing technical and financial support for these regulatory efforts [33, 38, 44].

Phase 2: Scaling Regulatory Reforms and Addressing Counterfeit Drugs (Medium-term: 2–5 years)

In the medium term, Afghanistan should expand its regulatory reforms to include stricter oversight of the pharmaceutical industry, ensuring that only quality-assured antibiotics are available on the market. Counterfeit and substandard drugs contribute significantly to AMR, and regulatory reforms should include measures to eliminate the distribution of counterfeit medications [33, 35].

During this phase, the government should also develop a national antimicrobial stewardship program (ASP) to promote responsible antibiotic use in hospitals and clinics. This program should involve regular audits of antibiotic prescriptions and the establishment of clinical guidelines for antibiotic use [38, 44].

Phase 3: Integration of AMR Initiatives into National Healthcare Policies (Long-term: 5+ years)

By the long term, AMR initiatives should be fully integrated into Afghanistan's national healthcare policies. The government should develop a national AMR action plan with specific goals, targets, and timelines for reducing the spread of resistance. This plan should involve all stakeholders, including healthcare providers, pharmacists, farmers, and international partners [33, 38, 44].

Public Education and Awareness

Phase 1: Launching National Civic engagement campaigns (Short-term: 1–2 years)

Public education is essential to curbing the misuse of antibiotics. In the short term, Afghanistan should launch a nationwide public awareness campaign to educate citizens about the dangers of antibiotic overuse or misuse. This campaign should target various segments of the population, including healthcare workers, pharmacists, and farmers [22, 24, 25].

Educational materials should focus on distinguishing between bacterial and viral infections, explaining the risks of self-medication, and emphasizing the importance of completing prescribed antibiotic courses. Engaging community leaders and local influencers will be crucial for building trust in these messages [22, 23, 25].

Phase 2: Tailoring Campaigns for Rural and Conflict-Affected Regions (Medium-term: 2–5 years)

In the medium term, public education campaigns should be tailored to the specific needs of rural and conflict-affected regions. Messaging should be culturally sensitive and delivered in local languages to ensure the broadest possible reach. Additional efforts should be made to combat misinformation, particularly regarding the use of antibiotics in traditional medicine [33, 38].

Collaboration with international NGOs and local influencers can enhance the effectiveness of these campaigns, helping to reach remote communities that might otherwise be excluded from public health efforts [38, 44].

Phase 3: Ongoing Public Health Education and Digital Campaigns (Long-term: 5+ years)

In the long-term, public health education should become an ongoing priority for the Afghan government. Digital campaigns, leveraging mobile technology and social media, can be used to reach younger populations and urban residents. Partnerships with tech companies and global health organizations can help sustain these efforts [38, 44].

International Support and Financial Aid

Phase 1: Securing Financial Backing for Critical Infrastructure (Short-term: 1–2 years)

Securing international financial aid is crucial for Afghanistan's fight against AMR. In the short term, Afghanistan should prioritize obtaining funding from organizations like the WHO, World Bank, and Fleming Fund to build diagnostic laboratories, equip hospitals with diagnostic tools, and train healthcare workers [33, 35, 38].

Phase 2: Long-Term Capacity Building and Technical Assistance (Medium-term: 2–5 years)

In the medium term, international donors should provide sustained financial and technical support to help Afghanistan develop its healthcare capacity. This includes training healthcare workers, improving laboratory diagnostics, and implementing AMR action plans. Partnerships with neighboring countries can also help Afghanistan manage cross-border AMR threats [33, 35].

Phase 3: Strengthening Regional Collaboration (Long-term: 5+ years)

Long-term international efforts should focus on strengthening regional collaboration. Afghanistan can partner with neighboring countries and international health organizations to share data and strategies for managing AMR across borders [33, 38].

10. Limitations

Despite offering a broad and policy-oriented analysis of antimicrobial resistance (AMR) in low- and middle-income countries (LMICs), this review has several limitations that should be acknowledged:

1. **Limited Availability of Uniform Prevalence Data**
   A major challenge in synthesizing AMR trends across LMICs is the inconsistency and scarcity of reliable prevalence data. Many countries lack comprehensive, up-to-date national surveillance systems, which restricts the ability to compare AMR rates across regions systematically. Consequently, the prevalence figures provided are drawn from a limited pool of studies and should be interpreted with caution.
2. **Narrative Review Design**
   This study adopts a narrative rather than systematic review approach. Although this allows flexibility in discussing a wide range of themes and integrating diverse sources, it may introduce selection bias and lacks the methodological rigor of systematic or meta-analytical reviews. Additionally, no formal quality assessment tools were used to evaluate the included studies.
3. **Language and Database Restrictions**
   The literature search was restricted to English-language publications and indexed sources available in databases such as PubMed and Google Scholar. This may have resulted in the exclusion of important gray literature or research published in local languages, particularly those from Francophone or Lusophone LMICs.
4. **Overlapping Themes Across Sections**
   Despite efforts to streamline content, there remains some thematic overlap—such as in discussions around over-the-counter antibiotic sales and public awareness gaps—due to the interconnected nature of AMR drivers. While repetition has been minimized, complete separation of themes was not always feasible without sacrificing depth.
5. **Underrepresentation of Country-Specific Interventions**
   While the review includes select case studies (e.g., Thailand and Rwanda) and examples from countries like India, Pakistan, and Nigeria, it does not comprehensively cover all LMICs. This was due to the uneven distribution of accessible data and literature, which limited the scope of comparative policy analysis.
6. **Focus on Human Health Sector**
   Although the manuscript briefly references One Health approaches, the primary focus remains on the human health dimension of AMR. Detailed discussions on AMR in veterinary, agricultural, and environmental settings in LMICs are limited, and future reviews should explore these sectors more holistically.

11. Conclusion

Afghanistan faces an urgent and growing crisis from antimicrobial resistance (AMR), fueled by the misuse and overuse of antibiotics, a weakened healthcare infrastructure, and insufficient public awareness. The prevalence of resistant pathogens, combined with the lack of effective surveillance and unregulated antibiotic sales, exacerbates this public health threat. Immediate and coordinated action is necessary to combat AMR and prevent it from overwhelming Afghanistan's already fragile healthcare system.

Global coordination is critical in Afghanistan's fight against AMR. Global partnerships can offer the technical expertise, financial aid, and policy guidance needed to implement effective interventions. By working with international organizations such as the WHO and the World Bank, Afghanistan can strengthen its healthcare infrastructure, establish robust AMR surveillance, and improve infection prevention and control (IPC) practices. Without such collaboration, Afghanistan's capacity to manage AMR effectively will remain limited.

Equally essential is the need for comprehensive public information campaigns. Educating healthcare professionals, pharmacists, and the general population on the responsible use of antibiotics is a fundamental step in addressing misuse. Public campaigns must focus on dispelling common misconceptions about antibiotics, promoting proper prescribing practices, and ensuring adherence to treatment protocols. Only through widespread public engagement can the culture of antibiotic mismanagement be transformed.

In summary, Afghanistan's next steps must include:

1. **Strengthening Healthcare Systems**: Improving healthcare infrastructure and expanding IPC practices are immediate priorities.
2. **Establishing a National AMR Surveillance System**: Developing a comprehensive, nationwide system to monitor resistance trends is essential for data-driven policymaking.
3. **Launching Social awareness drives**: Educating the public and healthcare providers on the risks of non-judicious use of antibiotics is critical to long-term success.
4. **Fostering International Partnerships**: Global partnerships will provide the resources and expertise needed to support Afghanistan's AMR strategy.

By prioritizing these efforts, Afghanistan can build a resilient healthcare system capable of managing and ultimately reducing the burden of AMR. The path to an AMR-free future is long, but with sustained commitment to reform, cross-country collaboration, and public education, Afghanistan can protect the health of its population and contribute to global efforts in combating antimicrobial resistance.

11. Declarations:

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All authors contributed significantly to the development of this manuscript. The contributions are as follows:

- **Hedayatullah Ehsan**: Conceptualization, overall supervision, manuscript drafting, and final approval.
- **Fazel Rahim Wardak**: Data synthesis and literature review.
- **Hasiba Karimi**: Literature review, data extraction, and manuscript editing.
- **Fariha Kamal**: Methodology design and manuscript revision.
- **Hasibullah Aminpoor**: Background and introduction drafting.
- **Abdul Salam**: Discussion writing and data visualization.
- **Hira Tariq**: Manuscript formatting and proofreading.
- **Rameen Damani**: Literature review and citation management.
- **Mohamed Nasser Elshabrawi**: Pediatric implications of AMR section and review.
- **Mehak Faisal**: Health policy analysis.
- **Chukwuagoziem Augustine Iloanusi**: Global comparison and intervention framework development.
- **Ayushmaan Roy**: Pharmacological aspects of AMR and critical review.
- **Izza Shakeel**: Editing and integration of various sections.
- **Sharvari Joshi**: Regional contextualization and references.
- **Md Abubakar**: Technical support and pharmacology review.
- **Abubakr Yosufi**: Afghan healthcare system challenges and local context.
- **Ahmad Jamshid Mehrpoor**: Data interpretation and co-supervision.

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Paper Context: This study provides a comprehensive analysis of antimicrobial resistance (AMR) in Afghanistan, focusing on the primary factors driving AMR and proposing strategic interventions. Addressing this issue is essential due to Afghanistan's limited healthcare infrastructure, which exacerbates AMR challenges. The findings and recommendations contribute to global efforts in AMR management and offer context-specific insights applicable to conflict-affected regions.

Main findings: Antimicrobial resistance (AMR) in Afghanistan is primarily driven by unregulated antibiotic use, insufficient healthcare infrastructure, and limited public awareness, with resistance rates exceeding 80% for key pathogens.

Added knowledge: This study highlights the urgent need for context-specific interventions in Afghanistan, identifying gaps in AMR surveillance, healthcare delivery, and public health education, especially in conflict-affected regions.

Global health impact for policy and action: Addressing AMR in Afghanistan has implications for global health security, suggesting that targeted investments in AMR surveillance, healthcare capacity building, and international collaboration are essential to mitigate AMR risks in similarly vulnerable settings.

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