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Review

Prevalence, pandemic, preventions and policies to overcome antimicrobial resistance

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A R T I C L E I N F O

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A B S T R A C T

Antimicrobial resistance (AMR) is a growing concern in Asia, and it is essential to understand the prevalence, pandemic, prevention, and policies to overcome it. According to the World Health Organization (WHO), AMR is one of the main causes of death; in 2019, it was linked to 4.95 million fatalities and caused about 1.27 million deaths. A core package of actions has been provided by WHO to help countries prioritize their needs when creating, carrying out, and overseeing national action plans on antimicrobial resistance. Using a people-cantered approach to AMR, the interventions address the needs and obstacles that individuals and patients encounter when trying to obtain healthcare. The people-cantered core package of AMR treatments seeks to improve public and policymakers; awareness and comprehension of AMR by changing the narrative of AMR to emphasize the needs of people and systemic impairments. Additionally, it backs a more comprehensive and programmatic national response to AMR, which emphasizes the value of fair and inexpensive access to high-quality healthcare services for the avoidance, identification, and management of drug-resistant diseases. The report signals increasing resistance to antibiotics in bacterial infections in humans and the need for better data. In conclusion, the prevalence of AMR in Asia is a significant public health concern, and it is crucial to implement policies and interventions to overcome it.

1. Background

The clinical context of antimicrobial resistance (AMR), reflects the possible outcome of treatment and efficacy of antibiotics in dispose of infections, often differs from its epidemiological aspect (Fouz et al., 2020). Hence, there is a lack of agreement on the definitions of AMR for epidemiological studies, and any such definition should take into account the following criteria (Pezzani et al., 2021):

i. At the level of the bacterial or host population, resistance needs to be considered a quantifiable (qualitative or quantitative) trait and defined in relation to a reference population (Corwin and Kliebenstein, 2017).
ii. Sensitivity, specificity, repeatability, and reproducibility of the detection technique must all be known and quantified (Kralik and Ricchi, 2017).
iii. It is important to precisely characterize the target bacterial and host populations, or those that the researcher is interested in (Ambriz-Aviña et al., 2014).
iv. The sampling framework needs to be fully defined, including the number of units (i.e., denominator data) from which samples are selected as well as the different levels of organization within the host or bacterial populations, or the environment (Lin and Peddada, 2020).

AMR can propagate both vertically, where the AMR genes are passed down from generation to generation, and horizontally, where bacteria share or exchange portions of their genetic material with other bacteria (Liu et al., 2022). As the bacteria circulate around the environment, the bacteria move themselves, the AMR spreads. Bacteria can travel across the water, on food, as well as on the people or inside the people (Koutsoumanis et al., 2021.,Kamal et al., 2022). The resistant bacteria can pass from an individual to other individual through coughing or unwashed hand contact. AMR can also by attributed by incorrect prescription of antibiotics. The antibiotics development lacks economic appeals due to relatively low cost of antibiotics. The over and misuse of antibiotics is also a major cause of AMR (Ullah et al., 2013., Rusic et al., 2021). Taking a look into these problems, we are on the edge of antibiotics therapy. The irrational prescribing, overprescribing incentives,

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self-medications, unqualified staff, lack of trainings, less availability of culture sensitivity tests, and incomplete dosing, are all consider as a great reason for AMR spreading (Koutsoumanis et al., 2021). In addition, the widespread usage of antibiotics, the ingestion of antibiotics in animals, inadequate pharmaceuticals, not enough monitoring, and other difficulties related to both individual and national poverty such as not enough access to health care, being hungry, recurrent and chronic illnesses, and the inability to afford more costly and effective medications, all have negative impacts on developing countries. Beside this, another obstacle in identifying approaches combat AMR is lack of novel medications (Liu et al., 2021).

Antibiotic prescriptions are getting better, which leads to better therapeutic outcomes and less AMR emergence. The improvement in antibiotics prescription, leads to better therapeutic outcomes and less emergence of AMR (Cantón et al., 2022). However, the emergence of AMR is triggered by the prescription of broad-spectrum antibiotics without a prescription. But considering the risk of multidrug-resistant hospital-acquired infections (HAIs), this may not always the case. As a first line of empirical therapy for the coverage of multiple microbes, broad-spectrum antibiotics should initially be started while awaiting the results of culture sensitivity testing (Chandra et al., 2021). The effective antimicrobial therapy depends on the early identification of causative pathogens through culture sensitivity tests and appropriate selection of antibiotics according to the results of the sensitivity reports (Maurer et al., 2017).

2. Prevalence of antimicrobial resistance

Based on the reports already published, Asia has the highest AMR prevalence in major bacterial pathogens, suggesting that it is obviously the global epicentre of AMR (Shrestha et al., 2022). In many countries, multidrug-resistant pathogens are widely spread in hospitals and communities. For instance, the most common cause of community-acquired pneumonia, Streptococcus pneumoniae, has a very high prevalence rate of macrolide antibiotics in Asian countries (Song et al., 2011). In China, large size of livestock sector and highest production and consumption of antimicrobials are the main factors that influence the unusual high AMR prevalence rates in major bacteria that infect Asian countries. In the year 2019, there were approximately 4·95 million AMR-related deaths, with bacterial AMR representing 1·27 million (95 % of the total) (Tang et al., 2023). At the regional level, the greatest mortality rate due to resistance, at 27.3 deaths per 100,000 people, is found in western sub-Saharan Africa, while the lowest death rate, at 6.5 deaths per 100,000 people, in Australasia, is estimated (Njoku, 2023). In the year 2019, About 1.5 million deaths were related to the resistance caused due to lower respiratory tract infections, these excessive deaths make it a troublesome infectious syndrome. In 2019, 3.57 million deaths attributed to AMR were caused by the six top pathogens for resistance-related deaths: *Escherichia coli, Staphylococcus aureus, Klebsiella pneumoniae, Streptococcus pneumoniae, Acinetobacter baumannii,* and *Pseudomonas aeruginosa*. More than 100,000 AMR-related deaths were caused on by *methicillin-resistant S. aureus* ("Universidad de Sevilla," 2023).

2.1. Causes of antimicrobial resistance prevalence

As the AMR is considered as a severe life-threatening emergency, causes more than 250,000 deaths annually. AMR has become global environmental and public health problem. The five major causes of AMR that contribute to its spreading are mentioned in Fig. 1.

2.1.1. Overuse and misuse of antimicrobial drugs

The overuse and misuse of antimicrobial drugs are one of the major causes of AMR. The extensive use of antimicrobial drugs is responsible for worsening the emergence of AMR. apart from this, prescribing antibiotic for viral infections, unserious to fulfil a prescribed course of antimicrobials and self-medications, are all the factors leading to prevalence of AMR (Town, 2014).

2.1.2. Agricultural overuse of antimicrobials

In many countries, large number of antimicrobial agents are in agriculture in handsome amount. They are considered to promote growth and preventing the infections in livestock. But unfortunately, these antimicrobials lead to the development and spreading of AMR in animals and humans (Gyawali and Ibrahim, 2014).

2.1.3. Global travel and trade

The ease and regularity of international trade and travel may give rise to the cross-continental spread of drug-resistant microbes. Since bacteria that carry genes for resistance can spread among people, animals, and the environment, the global travel and trade can also lead to AMR prevalence (Frost et al., 2019). Another significant factor contributing to the high prevalence of AMR in humans is the widespread consumption of antibiotics in the food chain (Bennani et al., 2020).

2.1.4. Lack of proper sanitation and clean water usage

The lack of proper sanitation and poor access to clean water can also

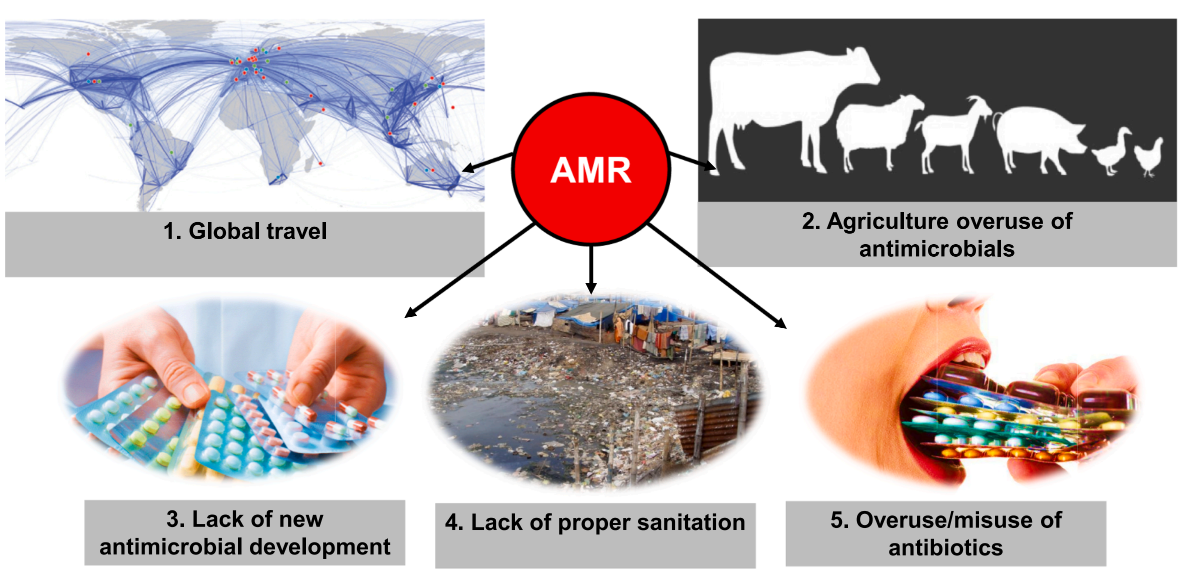

Fig. 1. The five major causes of antimicrobial resistance (AMR).

lead to the persistence and spreading of infections, this causes increased need of antimicrobial treatment (Samreen et al., 2021). Hospital water was considered to be a hotspot for AMR transmission due to the increased exposure to antimicrobials load, poor sanitation and drainage system, as well as interaction between environmental and clinical microbes (Huijbers, 2016).

2.1.5. Lack of new antimicrobial drug development

The discovery of novel antimicrobial agents is lacking; the microbes have become resistant to the already discovered antimicrobials. The bacteria were identified to be both potentially infectious agents and producers of bioactive metabolites after being isolated and cultured (Debbab et al., 2010).

3. Pandemic of antimicrobial resistance; a future threat

Before the outbreaks of COVID-19, the WHO claimed about AMR, reported in 2021, which states that AMR is making COVID-19 patients' outcomes more difficult because of extensive overuse and abuse of antibiotics (Ukuhor, 2021). This worsening will gradually and systematically increase AMR rates worldwide. Meanwhile, the policymakers should give much more thought to the hidden threat linked to AMR in the future, which may be worsened by the inappropriate use of antibiotics used to treat patients with severe COVID-19 infection. By considering this, the death toll related to AMR could be increased to 10 million by the year 2050, from the current estimate of 700 thousand deaths per year (Dadgostar, 2019). By looking into the following associated risk and factors, mentioned in Fig. 2, AMR is proved to be one of biggest challenge, silent future threat, and global pandemics.

3.1. The burden of transmittable disease

Since last six decades, AMR complications reduces the effectiveness of existing antimicrobial treatments. Thus, create difficulties in overcoming the transmittable or infectious diseases, such as; various bacterial infections like tuberculosis (TB), typhoid and many more, these difficulties result into many challenges in the treatment (Bergkessel et al., 2023).

3.2. Restricted approach

The restriction and unavailability of the benefits provided by healthcare results into insufficient diagnosis and inappropriate use of antimicrobial drugs. Due to this the people not acquired the right treatment and fail to take prescribed medications, this ultimately contributed to AMR spreading (Virhia et al., 2023).

3.3. Lack of awareness while use of antimicrobials

Due to lack of awareness on how to use antimicrobial agent. The antimicrobials are used without proper prescription of health centre and often taken frequently without any need. Additionally, the antibiotics are used for viral infections that lead to strengthen the resistance of microorganism to the antimicrobial agent (Bergkessel et al., 2023; Fouz et al., 2020).

3.4. Limited treatment

The effective treatments for *gonorrhea, chlamydiasis, syphilis, M. genitalium,* and *trichomoniasis,* consist of ceftriaxone, doxycycline, penicillin, moxifloxacin, and nitroimidazoles like metronidazole respectively. Due to worse spreading of AMR, limited options treating the *gonorrhea* and *M genitalium* are left (Rijal et al., 2021).

3.5. Increased morbidity and mortality

AMR persistency is connected to a greater probability of treatment failure and worsening infections, which are major causes of higher rates of morbidity and mortality and continuously rising of healthcare expenses (Majumder et al., 2020).

3.6. Healthcare burden and economic impact

Modern healthcare systems around the world are burdened due to significant economic and public health expenses as a result of the rising levels of AMR (Ahmad and Khan, 2019).

In the near future, due to the above parameters, the pandemic of AMR will emerge with more severity. This can lead to severe public health consequences effectively, which will not only impact the country's health system but also the economy as well. Yet the spreading of AMR can be overcome by appropriate awareness.

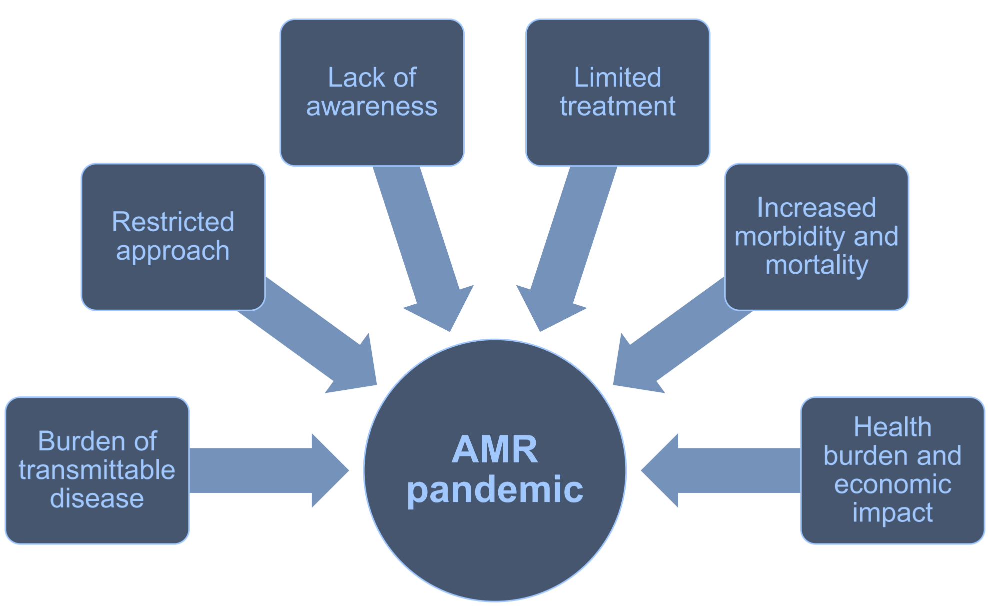

Fig. 2. The AMR: a future pandemic and its associated risks and factors.

4. Strategies for antimicrobial resistance prevention

Strategies to prevent AMR involve a wide range of approaches designed for reducing the emergence and spread of drug-resistant microorganisms. These strategies include various sectors, such as; healthcare, agriculture, and public health. Healthcare-acquired infections (HAIs) affect patient outcomes and provide suggestions for system costs for the Australian healthcare system (Fernando et al., 2017). The higher rates of AMR spreading demand enhanced HAI management. Healthcare workers and an unhygienic hospital environment are considered responsible for the spread and survival of pathogens such as *Clostridium difficile* as well as multi-resistant organisms (MRO) (Chua et al., 2022). As a result, a number of HAI prevention campaigns was given immediate attention. Core components consist of:

i. Antimicrobial stewardship: for minimizing overuse and promising evidence-based use of antimicrobial agents.
ii. Controlling multi-resistant organisms through infection prevention approaches, in particular methicillin-resistant Staphylococcus aureus (MRSA), vancomycin-resistant Enterococcus species, and multi-resistant Gram-negative bacteria.
iii. Enhanced institutional serving on hospital cleaning, disinfection, and hand hygiene.
iv. The establishment of standards of care and prescription guidelines (Salah et al., 2021).

Successfully implementing these strategies requires modifications in culture at the local hospital level and enhanced collaboration at the national level in order to combat the serious emergency threats posed by AMR. Multiple approaches must be employed to prevent healthcare-acquired infections, along with widespread healthcare collaboration, strong staff accountability, and support (Fernando et al., 2017).

5. Policies at state level to overcome microbial resistance

AMR is a serious global health challenge, requires comprehensive strategies and policies at various levels to address its influence. At the state level, the prevention policies should be implemented by governments, which can play a crucial role to effectively tackle AMR. More than 100 low- and middle-income countries established their own national action plans (NAPs) in response to the global action plans on AMR in 2015 (Charani et al., 2023). In Fig. 3, some of the state-level prevention policies have been mentioned, which can be implement, to cope with AMR.

5.1. WHO/CDC policies for AMR implementation, prevention and control

World Antimicrobial Awareness Week is a significant worldwide initiative that takes place every year from November 18–24. The slogan of the campaign is “Antimicrobials Handle with Care” under the theme “Spread awareness, stop resistance”. The objective is to raise public, health professional, and policy maker awareness of the threat posed by

Fig. 3. State level policies to overcome AMR.

AMR and how to collaborate in reducing the emergency and spreading of drug-resistant infections (Wu et al., 2021).

Since the global action plan adoption, more than 100 low- and middle-income countries have established their own national action plans, but unavailability of local data for supporting the decision-making and resource allocation have become a barrier in implementation (Chua et al., 2021). CDDEP/OHT researchers focus to support the WHO member states by reviewing progress in implementation of national action plans, developing AMR snapshots at country- and regional-level, and building an economic case to cope the AMR emergency (Light et al., 2022).

At the “STI & HIV 2023 World Congress,” which took place in Chicago, America, on July 24–27, 2023, the WHO recently provided its most recent guidelines on sexually transmitted infections (STIs) (Neglected et al., 2023). The WHO demands enhancement in access to testing and diagnostic services as a result of the reported increase in STIs. WHO also presents its most recent agenda for AMR and STI research in gonorrhoea at the congress (Vermund et al., 2020).

5.2. AMR stewardships

Antimicrobial stewardship programs in healthcare to facilitate the promotion of safe use of antimicrobials. These programs involve educating the providers of healthcare about responsible prescription practices, monitor the use of antibiotics, and implementation of protocols that ensure the demand intake of antibiotics (Pollack et al., 2016). The wide range of anthropogenic disruptions in natural microfauna caused by the widespread use of antibiotics is the main cause of AMR. The emergence of corona virus in 2019 crashed the antibiotics stewardship and solely rise the global antibiotics consumption as well as the biocide and personal protective equipment (PPE), made the existing global AMR problems more worsen (Rizvi and Ahammad, 2022). Therefore, in order to effectively remove residual PPCPs from wastewater, it is necessary to minimize the use of antibiotics, enthusiastically adopt antimicrobial stewardship, and improve the current state of WWTPs (Dionísio, 2019).

5.3. Control use of antibiotics

International and national campaigns about the control use of antimicrobials draw the global attention to use the presently available antibiotics in rational way (Roca et al., 2015). This attention has got importance due to high rates of prevalence of drug-resistant pathogens, including *vancomycin-resistant enterococci (VRE)* and *methicillin-resistant Staphylococcus aureus (MRSA),* as well as due to resistance development and worse spreading in Gram-negative rod-shaped bacteria (Church and McKillip, 2021). The objective of implementing antibiotic stewardship programs is to maintain antibiotic efficacy through careful use of currently available antibiotics. The main objective of antibiotic therapy is to effectively treat individual patients with bacterial infections (Nemeth et al., 2015). The best clinical treatment results can only be achieved, when minimize the toxicity, pathogens selection, resistance development (Yu et al., 2017).

5.4. Social and religious responsibilities for AMR control and rational use

Social and religious responsibilities play a crucial role controlling the emergence of AMR and rational use of antibiotics. The fight against AMR can be contributed by raising awareness, promoting responsible behaviours, encourage the adherence to ethical practices (Chaintarli et al., 2016). Here are some of the social and religious aspects which can support AMR control and rational antibiotic use:

5.4.1. Social responsibility

Community members, such as; individuals, families, and community leaders, have responsibility of raising awareness about AMR and importance of rational use of antibiotic (Chowdhury and Chakraborty, 2017). A multidisciplinary approach for tackling AMR, the input from biological and medical sciences as well as from social sciences are required (Calvo-Villamañán et al., 2023). Some strategies from education and psychology are suggested to increase awareness about AMR and to implement more effective interventions. Through educational campaigns useful information on proper use of antibiotic and the consequences of misuse can be deliver in better ways (Shehadeh et al., 2016).

5.4.2. Religious responsibility

The religious platforms can be used by religious leaders and organizations, to address AMR as a public health concern. As the Hajj is annual religious mass gathering event held in Makkah, Saudi Arabia. As millions of participants come to attend Hajj from across the globe, high risk of importation, transmission, and global spread of infectious diseases is associated. The emergency imposed by AMR is a global concern and the Hajj can make a serious risk for its spreading. So, they can integrate messages related to AMR control and antibiotic stewardship into their sermons, religious teachings, and community gatherings (Bokhary et al., 2022). Faith-based organizations play an important role in combating AMR. A workshop in late 2016 brought together experts from the faith-based health sector to discuss and identify actions to strengthen faith-based engagement in combating the emergence and spread of antimicrobial resistance. This emphasizes the role of religious organizations and communities in addressing the ethical issues raised by AMR. Religious leaders can incorporate messages about the significance of responsible antibiotic use and the dangers of AMR into their sermons, teachings, and community activities. Faith-based healthcare providers, who are frequently significant healthcare providers in many countries, can collaborate with other healthcare organizations to develop and implement best practices for antibiotic use and infection control. Religious leaders can use their influence and reach within their communities to mobilize support for AMR policies and encourage collective action to address this global health challenge (Word Health Organization, 2019).

5.4.3. Encouraging hygiene practices

By Social and religious way, the AMR drivers in some poor and underdeveloped countries are related to some forces that shaped these nations, such as; the political, economic, socio-cultural, and environmental forces (Jafari Sadeghi et al., 2019). Moreover, encouraging and practicing good hygiene, like regular handwashing, can help in reducing the spread of infections and the need for antibiotics (Esfandiari et al., 2016). Religious teachings often emphasize cleanliness and hygiene as part of spiritual purity. Religious leaders can emphasise these values and promote hygiene practices. By doing this, the risk of infections will be reduced, ultimately reduce the emergency of AMR (Sulis et al., 2022).

5.4.4. Community/retail and clinical pharmacist responsibilities

Community/retail pharmacists and clinical pharmacists play essential roles in promoting AMR control and rational antibiotic use (Wong et al., 2021). They have the responsibilities cover various aspects of patient care and public health, such as; they focus on ensuring appropriate antibiotic prescribing, dispensing, and patient education (Saleem et al., 2022). Here are some key responsibilities of community/retail and clinical pharmacists in the context of AMR:

5.4.4.1. Dispensing antibiotics appropriately. Community pharmacists must ensure that antibiotics are dispensed only with a valid prescription from a licensed healthcare provider. Community pharmacists are reputed to dispense antibiotics often without a prescription, which raises the risk of AMR emergency (Rusic et al., 2021). Community pharmacists believed that irrational use of antibiotics and subsequent development of AMR were caused by patient’s behaviour and the social environment (Jamshed et al., 2018). They should verify the prescription’s accuracy, appropriateness, and adherence to local guidelines

(Löffler and Böhmer, 2017).

5.4.4.2. Educating healthcare providers. The Clinical pharmacists can educate other healthcare providers including the physicians and nurses, about rational antibiotic use, resistance patterns, and the importance of following local guidelines (Sakeena et al., 2018). According to a study, nearly 90 % of the total amount of antimicrobials consumed were taken orally; Roughly 77 % of oral intake was comprised of up of macrolides, fluoroquinolones, and third-generation cephalosporins. The proper - consumption of antibiotics as prescribed by attending physicians must be promoted by pharmacists; doing so will educate hospitalized patients as well as healthcare providers (McEwen and Collignon, 2018).

5.5. Hospital pharmacist responsibilities

AMR is nowadays a significant health problem globally, especially in low- and middle-income countries) where no efficient implementation of antimicrobial stewardship initiatives took place yet. In hospital antimicrobial stewardship teams, pharmacists have been allocated a crucial role in antibiotic governance; however, little attention has been given to their experience in influencing antibiotic use (Broom et al., 2016). To evaluate hospital-based pharmacists' perspectives and experiences regarding antibiotic use and governance through conducting 19 semi-structured interviews. By means of the framework approach, the analysis was carried out using the NVivo10 software (Penm et al., 2019). Principal findings from the interviews with pharmacists include:

i. The pharmacists are responsible for optimising use of antibiotics and interprofessional challenges.
ii. The necessity of streamlining antibiotics usage and obstacles face by pharmacists to do so.
iii. The pharmacists' expertise in antibiotic optimization is often underutilized, despite of its potential (Broom et al., 2015).

In antimicrobial stewardship teams, pharmacists play a vital role, but their capability to contribute to change is restricted by embedded interprofessional dynamics. The implementation of hospital policies aimed at optimizing antibiotic use will be significantly impacted by the recognition of how hospital pharmacy's antibiotic controlling is limited by the organizational setting and embedded in the interprofessional nature of clinical decision-making (Broom et al., 2019). Pharmacist's ability to overcome interprofessional barriers through the development of stronger collaborative relationships by shortage of resources, especially time limitations and task prioritization (Hatton et al., 2021). This implies that to have positive impact on the use of antibiotics in hospitals, pharmacists should have more influence over doctors, be more visible on hospital wards, and have the chance to share their specialized knowledge with multidisciplinary clinical teams (Broom et al., 2016).

5.6. Academia responsibilities for antimicrobial resistance control

Academia plays a crucial role in AMR control by generating knowledge, conducting research, and educating future healthcare professionals and the public as well. Academic institutions have unique responsibilities to address AMR comprehensively (Ferri et al., 2017). Academia should conduct research to understand the mechanisms of AMR, including how resistance develops and spreads among various pathogens, as standard microbiological assays can easily identify AMR, and the threat posed by AMR is widely recognized (Carrique-Mas et al., 2020). In order to effectively combat AMR, recent advances in the development of novel antibiotics and inventive diagnostics, as well as detection techniques and innovative strategies aimed at eliminating bacterial persisters, are also needed (Shang et al., 2020).

AMR poses a serious risk to world health, thus need of the day is progress in research and development of novel antimicrobial drugs. To ensure long-term patient access to new treatment options and minimize the global burden of AMR, pharmaceutical industry and academic institutions should promote antimicrobial research and development (R&D) (Mattar et al., 2020). Academia can foster interdisciplinary collaboration among scientists, healthcare professionals, veterinarians, environmental experts, and policymakers to adopt a One Health approach for AMR control (Zhang et al., 2023).

5.7. Student's social awareness campaigns for antimicrobial resistance

Since AMR is a worldwide health issue, it is crucial to raise awareness among young students. The purpose of an AMR roadshow designed for stage 4 students was to assess the students' previous knowledge of AMR, take their learning "outside of the classroom," and find out how the roadshow affected their retention of the material. Using a standardized questionnaire, knowledge and subsequent retention were assessed both before and after the event. Approximately twelve-week period was observed during which the roadshow significantly enhanced the understanding and knowledge of AMR. Key health issues were addressed through interactive and engaging strategies that enhance the learning process and help young learners retain what they have learned (Ahmed et al., 2020).

6. Recommendations for antimicrobial resistance policy implementation

In order to combat and succeed over AMR, countries must develop and implement their comprehensive strategic action plans (Balkhy et al., 2016). This is particularly crucial because the COVID-19 pandemic management has recently consumed the majority of resources and workforce (Bourgeault et al., 2020). Delivery of healthcare is a complicated adaptive process, and in order to address the AMR challenge and promote long-lasting change, appropriate systemic adaptation is needed (Sadowska et al., 2021). In order to provide a comprehensive policy package to combat AMR, all stakeholders, lawmakers, and partners in the health systems should be involved, not only in the complicated system of COVID-19 but also AMR itself too, as it is to be expected to adopt pandemic shape in near future (Dayrit et al., 2018). Moreover, in the complex and adaptive system of peoples, processes, resources, institution, adopting a system approach is crucial. Beside this, assisting in the implementation of long-term interventions requires leadership, accountability, and transparency along with support for resources, such as funding, strategy, data utilization, management, and capacity (Sachs et al., 2019).

7. Failure, hurdles and limitations to overcome antimicrobial resistance at state level

As AMR is a worldwide health crisis that arises when bacteria, viruses, fungi, and parasites develop resistance to the medications used in the treatment of infections (Dhingra et al., 2020). Overcoming AMR requires a multifaceted approach at the state level, involving coordination among various stakeholders, like the researchers, policymakers, healthcare and the public (Singh et al., 2019). However, there are several hurdles and limitations that may delay the progress in combating AMR at state level. Some of these include; the misuse of antibiotics as the patients are prescribed with wrong doses and incorrect route of administration (Mira et al., 2015). There aren't enough AMR awareness campaigns that specifically target the animal production industry, especially in low- and middle-income nations (Dankar et al., 2022). The goal of synthetic biology techniques is to discover natural products more rapidly than previous antibiotic discovery methods through a combination with molecular, functional genomic, and metagenomic studies of bacteria, plants, and even marine invertebrates. As there are currently few effective treatments, few preventive measures that could be taken, and few antibiotics available, new medical approaches and antimicrobial therapies must be developed (Uddin et al., 2021). Globally, the emergence in infectious cases triggered by AMR pathogenic microbes poses a serious threat. Unfortunately, current antimicrobial preparations have not been effectively utilized to tackle this problem. We aimed to address the significance of finding new synthetic or naturally occurring antibacterial compounds to manage AMR, given the emergence of pathogen resistance and the insufficient supply of effective antimicrobials (Nainu et al., 2021). Since this problem obviously impacts human health, creative and careful approaches to employ different drug delivery methods to deliver those novel antimicrobial compounds through multiple routes will yield beneficial strategies to the management of infectious diseases (Yeh et al., 2020). However, in order to avoid the emergence of resistant pathogens to the newly developed antimicrobial agents, it is necessary to carefully design the delivery systems for various infectious diseases (Gupta et al., 2019). At the end of the day, everyone will gain significant benefits from careful considerations in the development of highly efficient drug delivery systems and affordable novel antimicrobials, including public communities, pharmaceutical companies, research institutes, and healthcare providers, and public communities (Beg et al., 2020). In the ongoing effort to combat the emergence of antibiotic-resistant pathogenic microbes, such collaboration will also offer an incredible scientific opportunity to link fundamental discoveries to clinical implications (Bhattarai et al., 2020). Future research is required to study and optimize the spread of CRISPR-Cas in more accurate microbial communities and to understand the risks accompanying this technology. In addition, the social and lawmaking challenges related to the widespread use of this gene-editing technology require active engagement with communities and development of clear guidelines to regulate its responsible and safe use (Hodge, 2007). The use of antimicrobial peptides (AMPs) can be a good substitute for existing therapeutic approaches assigned the scope of AMR. Because AMPs are widely available in nature, synthetic chemists may synthesize semi-synthetic peptide molecules. AMPs exhibit a wide range of activity towards microorganisms and may overcome their resistance induction mechanisms (Gan et al., 2021).

8. Conclusion

In conclusion, this article enlightens the alarming prevalence of AMR, which poses a significant threat to health globally. By looking into the relation between AMR and pandemics, we highlighted the potential for these drug-resistant infections to exacerbate the severity and spread of infectious diseases. In this article, we also emphasize on the urgent need for prevention strategies to address AMR effectively. This includes promotion of responsible use of antimicrobial agents, implementation of infection control measures, and raising awareness among healthcare providers and general public. By emphasizing the importance of multi-sectoral approach, we underscore the significance of collaboration of between the health professional, policymakers, and researchers to tackle this emergency issue. Furthermore, we explored the critical role of policies in controlling AMR. We discuss the need for robust surveillance system to monitor resistance patterns, facilitate early detection, and guide appropriate treatment decisions. Additionally, we also focus the importance of incentivizing research and development of novel antimicrobial agents to cope emerging resistant strains. So overall, if these strategies implemented, it will be somehow help in combating the emergency on AMR.

CRediT authorship contribution statement

Ghallab Alotaibi: Conceptualization, Data curation, Formal analysis, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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