Vol. 5 No. 1 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387 | Print ISSN 3007-2379

Emergence of Multidrug Resistance Through Healthcare Practices Agriculture Expansion and Biofilm Adaptations

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Received on 12 March, 2026

Accepted on 02 April, 2026

Published on 03 April, 2026

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Abstract

Nowadays, it is mainly considered as the most serious health issue all around the globe, and its impact is felt directly in the food industry's safety and technological advancements. Thus, the problem of resistance is a worry for everyone no matter how old they are or where they live. The most potent veterinary antibiotic that is still in use globally is progas, but it is mainly thought that the antibiotic usage has increased the contact among the animals. In many cases, the toxins are being transmitted to the already vulnerable ones and at the same time, the microbes are getting even more resistant - pneumonia, tuberculosis, goat disease, salmonella, etc. Infection control consisting of prevention and treatment is one of the measures among others. Microorganisms indeed, it is truly a sight, receive anti-inflammatory power together with their change in prescription. Bacterial activity might be the cause of the illness in some and in this case, the immune system is the most destroyed one. Besides, immunization leads to increased medical costs and the healthcare system has to be ready for emergencies while it is also killing the population.

Keywords: Disease prevention, immunization, drug therapy, drug resistance, Medical treatment, Healthcare systems, Preventive measures

Introduction

The improper usage of antibiotics in the medical field has contributed to the growing problem of antibiotic resistance; additionally; the increased use of antibiotics in agriculture has resulted in even more development of antibiotic-resistant bacteria. Examples of these bacteria include MRSA and Acinetobacter spp., which have formed biofilm structures that allow them to be more resistant to antibiotics. There is also an increase in the over-prescription and misuse of antibiotics in the clinical setting, which adds additional pressure to the development and growth of antibiotic-resistant forms of bacteria. MRSA and A. baumannii are two such bacteria that can form biofilms; therefore, these bacteria are able to survive longer on medical devices and surfaces at hospitals, making it more difficult for the patient to receive successful treatment upon admission. Biofilms may also serve as a location where antibiotics may have difficulty infiltrating or being effective. Addressing these problems will require an integrated "One Health" approach to use of antibiotics appropriately, prevention/infection control measures, surveillance, and sustainability in agriculture [1].

The overuse of antibiotic usage within livestock to help them grow or prevent disease also leads to creating resistant bacteria in the environment. These resistant bacteria could enter humans through contact, contaminated food, or the environment. The inability for researchers and scientists to treat infections with classic antibiotics due to their inability to create resistance, has made it more difficult to treat patients with infections due to the clinically safe antimicrobials, like Gram negatives and non-steroidal anti-inflammatory drugs as well [2]. Recent studies indicate that there will be three levels of classification required when determining which microorganisms should be treated in cancer patients and what their treatment will involve micronization.

The primary cause of emotional effect that led to the emergence of resistant strains was the introduction of contaminates, along with indiscriminately exposed individuals. The presence of non-microscopic active agents may cause viral spread in extremely high numbers of victims, creating difficult immunisation of resistant strains in hospitals over a long period of time due to strong antibacterial control mechanisms. Antimicrobial resistance for many microbe species is related to their usage and potency combined with other factors and immune problems/diseases — usually having no cure or a valid preventive measure — making the discovery and application of any method of treating with antibiotics difficult. Increasing knowledge of mechanism(s) of resistance and the production systems of antimicrobial(s) is providing more avenues for control and prevention of microbe disease(s). Specific microorganisms present in individuals' living conditions, loss of specific microorganisms through multiple stressor types, as well as the role of specific microorganisms provide a basis for a bacteria-human relationship in the microbiota.According to the researchers, there exists a conflict as to whether pathogens can be effectively treated by using bacteria. There may also be a delay in recovery if the individual is suffering from an extreme infection, regardless of how one views the severity of their illness prior to receiving treatment. In some cases, an individual's body may deteriorate rapidly because of other viral infections. One of the many contributors to the increase in infections is an increase in the resistance to antibiotic treatments due to certain bacterium's growing resistance to antibiotics. Because of the extremely slow process of drug discovery (and thus development) which is expensive and time consuming (whereas only a few pharmaceutical companies exist within this field), the US needs to establish a strong and organized healthcare system that provides support (to not only individuals), but to their families as well. This is especially true, in addition to having improved methods for diagnosis, increased accessibility for individuals requiring emergency care, and response times of healthcare staff in emergencies.

1. Discovery of Antibiotics

The first antibiotic was discovered by Sir Alexander Fleming in 1928 (Penicillin), the beginning of the modern era of antibiotics. The invention of Penicillin changed the future of medicine and allowed for the treatment of bacterial infections that could not be treated before. In addition, the discovery of Penicillin opened up a new possibility of using microbial products to treat illness, but it also foreshadowed some of the problems that we would face later, such as misuse and resistance to the drug [5].

2. Emergence of Antibiotic Resistance

Since its introduction, methicillin had only been in use for about a decade when methicillin-resistant Staphylococcus aureus (MRSA) surfaced, showing us how fast bacteria can adapt and become resistant to medication. The development of resistance is caused by microbial adaptation, horizontal transfer of genes, and selective pressure resulting from the wide use of antibiotics. The growth and survival of resistant strains has a negative impact on the effectiveness of the drugs used to treat people who have infections caused by them. Therefore, researchers must continue to develop new agents to treat these types of infections [6].

3. Impact on Vulnerable Populations

Individuals affected by cancer and organ transplantation and those with chronic diseases such as diabetes or kidney failure often take antibiotics, so these drugs have an important impact on their health. There are many ways that infection control can make it difficult for patients who are affected by these factors to access antibiotics or can impose strict requirements for their use. However, regardless of these obstacles, antibiotics will continue to play an integral role in managing infections after surgery, treating immunosuppression caused by chemotherapy, and providing treatment for patients who have undergone complex medical interventions [5].

4. Modern Antibiotic Use and Diagnostics

The amount of antibiotics used all around the world has been increasing at a record rate which makes antibiotic stewardship vital. Research comparing consumption of antibiotics to patterns of resistance indicates that there is a connection between the volume of antibiotic use in an area and the risk of new bacterial resistance developing [7]. Newer, molecular diagnostic tests such as PCR, have improved our ability to identify pathogens in illnesses such as community-acquired pneumonia and enable us to provide faster and more accurate treatment options than ever before. Also, these advances continue to highlight the ongoing need for proper management of antibiotics.

The horizontal spread of the agricultural land

Antibiotic application in livestock rearing of animals treated as pets might be viewed, after good hygiene, as the second most important factor. In the United States, farmers account for the majority of the total toxins purchase which are designed for animal's

Online ISSN 3007-2387 Print ISSN 3007-2379

growth and sickness prevention [8]. The whole process from providing pet-like care to an animal, spraying, and finally to a fully grown animal that produces more and thus brings more profit to the farmer is the main objective. The question arises, however, as to whether the animals and the food, the hot or cool food, and the food antibiotics package are all together? It is over thirty-five years that the 'pet-like' artificial beings were turned into humans, and besides preventing diseases and pesticides for both pets (and weeds), controlling them also took place; and, in the case of farmers, nuclear identification systems were developed, and excellent microscopic waste and cattle bases were achieved by consumers with meat products. Even though this is a lengthy process, it occurs either by the death of the protective microorganisms that allow the antibodies to grow or by their elimination. A secure microscope probe is sent to the supermarket for analysis. The lesion that is under microscopes is. IDSA's aspiring network presented a general overview of infectious diseases in 2011, more than 60% of the researchers marked safe bacterial terminal infections in the first year or so [9]. There are many lawyers with moods and good bacteria, sometimes all this leads to emergency and even catastrophic incidents. In 2013, the CDC reported that the public was already in "exchange times" and in 2014 the WHO warned that the early sale of unexpected predictions was becoming progressively more severe. MDR microorganisms were acknowledged by IDSA and other health authorities as a great risk to public health and safety in the USA as well as in healthcare. The increase in the population of Gram-negative MDR Bacilli (and the low-carb diet) has an influence on all pharmacokinetic processes. The most common Gram-negative agents in healthcare or Enterobacteriaceae areas are (typically Klebsiella pneumoniae), Pseudomonas aeruginosa, and Acinetobacter. These strains gain access to the beta-lactamases developed by E. coli and Neisseria gonorrhoeae [10]. However, MRSA was extremely adaptable to different epidemiological contexts (publication types, geographical areas, the youngest animals) and gradually came to be. This made it difficult to test the prevalence of MRSA for diseases and led to an experimental approach with contamination control plates targeting only HAI-related contaminants. The conditioning of those medical practitioners who are unfriendly to MRSA is generally through change, yet, despite that, the protection of those bacterial strains remains, which is done with toxins and glycopeptides, and this is a major concern.

Antibiotic Resistance Risks

Antibiotic resistance has emerged as a critical global health challenge, driven by a combination of clinical, agricultural, and environmental factors. In healthcare settings, the overuse and misuse of antibiotics create strong selective pressure, promoting the emergence and dissemination of resistant pathogens such as methicillin-resistant Staphylococcus aureus (MRSA) and multidrug-resistant Acinetobacter species. These bacteria often form biofilms on medical devices and hospital surfaces, which protect them from host immune responses and limit the efficacy of antibiotics, resulting in persistent infections. Simultaneously, agricultural expansion contributes to resistance through the widespread use of antibiotics in livestock for growth promotion and disease prevention. These practices create environmental reservoirs of resistant bacteria that can enter human populations via food chains, water, and direct contact, highlighting the interconnected nature of resistance under the One Health framework. Studies have shown that MRSA and Acinetobacter biofilms are particularly adept at surviving in both clinical and environmental niches, complicating infection control efforts and treatment strategies [1]. Addressing this issue requires coordinated interventions, including rational antibiotic stewardship, stringent infection control, continuous surveillance, and sustainable agricultural practices to mitigate the global threat of antimicrobial resistance.

The use of antibiotics in healthcare environments

VRE is one of the most pronounced issues in the area of healthcare-associated infections. In fact, Enterococcus is one of the major pathogens, which can be easily identified in case of disease occurrence, especially in hospitals [11]. Surprising as it may be, the worldwide impact of enterococcus and other factors is very limited, mainly covering the U.S. and parts of Europe, and even the impact is greater than that of MRSA. The annual estimate of VRE cases associated with healthcare in the U.S. is in the hundreds of thousands, which leads to a significant amount of illness and even death. Hospital strains of VRE are the ones mostly accountable for the spread of resistant bacteria, which are already present in the hospital and dependent on the hospital's Enterococcus state. The mere presence of Enterococci is said to have led to high vancomycin use among outpatients and inpatients, with associated adverse outcomes. In 2012, it was reported that drug-resistant tuberculosis (TB) had already infected thousands and still is, posing challenges globally in the treatment strategies [12]. Mycobacterium tuberculosis is capable of infecting a number of organs, however, lungs remain the most common site. Resistance differences amongst tuberculosis cases in the U.S. are showing a very high rate of isoniazid resistance in total cases. Tuberculosis treatment is still quite a challenge mainly due to the lack of effective treatments and the slow process of introducing new drugs. The presence of Pseudomonas aeruginosa, the main bacterium responsible for hospital-acquired infections such as pneumonia, blood poisoning, urinary tract infections and skin infections, is under constant surveillance. Multidrug-resistant (MDR) strain of P. aeruginosa accounts for approximately 13% of total hospital infections. Over a hundred locations every year have been shown to be the source of these infections. Some strains of antibiotic-resistant Pseudomonas aeruginosa can withstand almost all antibiotic treatments [13]. However, they still can be treated with a few classes of antibiotics that are already in clinical use. The U.S. healthcare system, beyond doubt, will forever be faced with its economic and social problems regarding disease prevention that will not only patients' lives but also those of their families' lives affected. One of these problems is antibiotic resistance which is undoubtedly the most crucial public health problems and extremely severe consequences. To give an example, in some cases, doctors along with other health professionals are literally forced to resort to the older or the first-generation antibiotics even when the patient's condition is asking for the latest ones to be used.

The data from treatment back this up by revealing that a significant number of patients are still getting admitted to hospitals, seeing specialists for a long period of time, and their recovery gets prolonged, while in some cases, they even end up being disabled for life. Pathogenic microorganisms and their complications are the root of these health problems. The immune system's reactions, which are at times accompanied by cell death, result in the development of bacterial resistance and the disease thereby wins its battle in its own way [14]. Among the properties of biofilms, the anti-inflammatory effect is the most significant one, but on the other hand, they may contribute to drug toxicity. The literature on biofilms has provided a number of resistance mechanisms to antimicrobials and thus is included in control strategies. The struggle with bacterial adhesion has become very reliant on antibiotics, and thus the use of such methods has become a very strict practice. It does not imply that the biofilms are not infective anymore when the antibiotics are applied to invade them. The biofilm research has been a headache for the scientific community worldwide, which is either rethinking the old or inventing new methods for biofilm research. Water samples have been collected by researchers from places that might be the source of either preventing or breaking down pathogenic biofilms in a hospital.

Biofilm formation by MRSA and Acinetobacter species

One of the key reasons why the clinical behavior of Acinetobacter baumannii is given so much importance is that it sheds light not only on the mechanisms behind biofilm development and antibiotic resistance in microorganisms but also on the possibility of infection treatment done in a more effective way [15]. To this end, the authors have come up with a very dense and top-quality mixed culture of Multisufferers (MDR) - MDR biofilms with Multisufferers (MDR). Along with the unreliability of water used for local MDR-positives and the very minor production of biofilm, the issue of no more than a few multis-chambered MDR partners being born at low double-digits has been raised. In this regard, large-scale cultivation of low-density partners with MDR negative biofilms is likely to have a 60% chance of occurrence. The scenario of collecting a huge bunch of MDRs is definitely bad for ecosystems; however, the factor that chiefly determines the situation is the extraordinarily high biofilm density. Moreover, the researchers have pointed out the interplay of antidepressants and mood and at the same time have offered very strong reasons for the opening of the dialogue among different medical and natural methods within the healthcare system that could be called the trade-off between the two [16]. A new diagnostic technique that was introduced played a significant role in decreasing the interactions between the medical staff and the methicillin-resistant Staphylococcus aureus (MRSA) patients who were included in the stimulant subgroup of this study. With the implementation of the individual and two-stage polymerase chain reaction (PCR) testing in the two-stage contracts, the inventor of the method was able to elevate the precision of the testing technique from 77% to a perfect score of 100%. The PCR method is quite expensive, however, it is still one of the most costly diagnostic techniques. Staphylococcus aureus is a quite sensitive microorganism and thus, the improper treatment of infections usually happens to its account. The period between the host's demise and the onset of the disease is the time when the microbe has the greatest power over the host. Staphylococcus aureus not only causes the production of large amounts of very potent toxins but also of a wide range of harmful agents such as chemicals and antimicrobial substances that are specific to a certain type of microbe and disease invading the skin which the host can not only withstand but also become imperceptible to and even undergo adaptation. Each therapy has its own criteria for differentiation of toxins and chemicals, and moreover, the toxicity of the substances under discussion is not the same for all methods [6]. As a result, staphylococci, the bacteria that are largely responsible for antibiotic resistance, find themselves in a dilemma regarding the safety of their spread as there are pros and cons to it. One of the factors that have received most attention in the context of resistant bacteria's escalation is the employment of square antivirals which can either kill the bacteria or cause the production of their toxins and making the latter as the main goal. The scientists not only find a way to break the deadlock in the method but also invent a procedure for the isolation of staph acid from Staphylococcus aureus. The presence of methicillin-resistant Staphylococcus aureus (MRSA) has been established in humans, animals, and through environmental changes. The authors' research encompassed the latest investigations into genetic selection and gene migration, the only ways different areas could be inhabited by the same species. Besides, the influence of the big pharma on the genetic profile of diseases, the controlling of antibiotic resistance leading to resistance, and so forth were subjected to scrutiny [17].

The authors suggest that if the cloning techniques are learnt then the physicians will be able to make therapeutic options that are very quickly dropping and upgrading, which will be a no longer farfetched idea. The effect of methicillin on MRSA is determined by the resistance behavior in the ICU, the conditions of the site, and the attributes of the site. It is no surprise that public health agencies have named community-acquired MRSA (Ca-MRSA) the leading cause of skin and soft tissue infections (SSTIs) and community infections; however, the link between Ca-MRSA control and disease rate is still poorly understood. The research did concentrate on

Staphylococcus aureus species' different forms and the places where they are found in the patients who have and do not have SST. The specified regions are the nose, esophagus, and lungs, where S. aureus' unexamined presence was associated with tumor-related damage in the USA. Staphylococcus aureus was identified by means of bacteria stimulation, and drug susceptibility tests were conducted on different strains of Staphylococcus aureus [18]. It was surprising that a considerable percentage of cancers had Staphylococcus aureus as a partner infection. Among the total, quite a number of strains representing both MRSA and MSSA were obtained. The confirmation of Staphylococcus aureus infections is mostly done by means of culture technique followed by PCR confirmation.

Difficulties associated with controlling drug resistance

The main assembly identified MRSA and the regions of the bacteria that were not transmittable. The process of getting rid of MRSA lasted for two years, and during this period, the patients were given HIV-1 baths, nasal mupirocin application, and the like [19]. The SAN was a method employed to continually keep track of the diseases or to bring to light any change in the disease. The bacteria were mainly distinguished by two characteristics, the presence of qacA/B cells and the ability to resist mupirocin. After the eradication process, there was a decline in the prevalence of MRSA of 61.6% ($P < 0.001$) in the first trial. The presented software architecture model was not only very effective in the reduction of MRSA rates but also in the shortening of their periods. The total number of isolates obtained from MRSA was

Antibiotic Resistance Drivers

A combination of factors (clinical &agricultural) has caused antibiotic resistance to pose an increasingly serious global public health issue. The overuse & misuse of antibiotics in health care settings creates high levels of selective pressure on resistant pathogens such as methicillin-resistant Staphylococcus aureus (MRSA) & multidrug-resistant Acinetobacter species, promoting their emergence & dispersal. Both MRSA and Acinetobacter frequently produce biofilm matters on surfaces of medical devices and on hospital surfaces; these biofilms protect the bacteria from host immunity and reduce the activity of antibiotics, leading to prolonged infections. The expansion of agriculture through the widespread use of antibiotics in livestock for growth promotion & disease prevention has also made a contribution to resistance. This allows for the creation of resistant bacterial reservoirs in the environment that can come into contact with humans via food, water & direct contact. Therefore, under One Health principle, there are strong linkages between resistance in the clinical and environmental context. MRSA and Acinetobacter biofilms presented in studies have shown a high capacity to survive throughout a variety of clinical & environment niches, which creates difficulties in controlling infections & providing treatment (BMC Microbiol 2022;22:113). A multi-faceted, co-ordinated approach utilizing the rational use of antibiotics; stringent infection control; continuing surveillance; & sustainable agricultural practices must be implemented to address the global threat that antimicrobial resistance poses.

Conclusion

It is safe to say that the global health system faced a significant challenge and a very difficult moment when it was to select the bacteria that had developed antibiotic resistance. The first ones to be given the status of drug-resistant organisms among these bacteria were tuberculosis, A. baumannii, and MRSA. So, the case is quite difficult and the health care systems are really suffering as they are without good antibiotics and are left with just a few treatments, which is why the number of cases and deaths is going up. The main reason for bacterial resistance can be narrated as two principal points; to start with, the capacity of the microorganisms to change their genetic makeup and to continue with the production of thick defensive barriers or biofilms which practically guarantee that no treatment can get rid of the infection. Rapid diagnosis, effective Zinfection control, new drug therapy, and worldwide cooperation have been crucial not just in battling these new threats but also in advancing public health.

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Pakistan Journal of Medical & Cardiological Review
https://pakjmcr.com/index.php/1/about
Online ISSN 3007-2387 Print ISSN 3007-2379

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