INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES
[ISSN: 0975-4725; CODEN(USA): IJPS00]
Journal Homepage: https://www.ijpsjournal.com

OPEN ACCESS

Review Article

A Review on Antibiotics Resistance : A Growing Threat

Aniket Raje Ghadage, Onkar Korade, Shubham Bansode*, Dr. R. R. Bendgude

Shri Ganapati Institute of Pharmaceutical Sciences and Research, Tembhurni. 413211

ARTICLE INFO

Published: 11 Nov 2025
Keywords:
Antibiotic resistance, pharmacists, antimicrobial peptides, global health, nanotechnology
DOI:
10.5281/zenodo.17580636

ABSTRACT

Antibiotic resistance is becoming one of the biggest health problems in the world today. It happens mainly because antibiotics are often used too much or in the wrong way in people, animals, and farming. When bacteria become resistant, infections are harder to treat, illnesses last longer, treatment costs more, and more people may die. This review explains how antibiotic resistance develops, how it spreads, and the important role pharmacists play in fighting it. Pharmacists help by making sure antibiotics are used properly, educating patients and healthcare workers, and supporting policies that reduce misuse. The review also looks at new ways to fight resistant infections, such as bacteriophage therapy, antimicrobial peptides, and nanotechnology. Using antibiotics responsibly and involving pharmacists in healthcare are key steps to protect these lifesaving medicines for the future.

INTRODUCTION

Penicillin was discovered in 1928; these drugs have saved millions of lives by turning infections that were once deadly into conditions that are usually easy to treat. They have allowed doctors to fight a wide range of illnesses and have made modern medicine much safer for everyone.

However, antibiotics are often overused. Sometimes people take them when they don't really need them, or they stop taking them too soon. This misuse gives bacteria a chance to adapt and become stronger, which makes some infections harder to treat. This growing problem is called antibiotic resistance, and it is becoming a serious concern around the world.

The World Health Organization has warned that if we don't change the way antibiotics are used, we could enter a "post-antibiotic era," where even minor infections might become dangerous and difficult to treat. This issue is not limited to hospitals—it affects communities, farms, and the environment as well.

Pharmacists have a key role to play in fighting antibiotic resistance. They have deep knowledge

***Corresponding Author:** Shubham Bansode
Address: *Shri Ganapati Institute of Pharmaceutical Sciences and Research, Tembhurni. 413211*
Email : shubhambbansode8177@gmail.com

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

of medicines and are often the healthcare professionals people can access most easily. By giving the right advice, guiding patients, and making sure antibiotics are used correctly, pharmacists can help slow down resistance and protect people's health for the future.

Reason for Antibiotics Resistance :

Several factors give rise to antibiotic-resistant bacteria: Overuse and Misuse The misuse and overuse of antibiotics are major reasons why many bacteria are becoming resistant to these medicines. When antibiotics are used the wrong way — for example, to treat viral infections like the flu or when people stop taking them too early — not all the bacteria are killed. The stronger ones survive, multiply, and spread, making future infections harder to treat. Overuse happens when antibiotics are taken too often or when they are used when not really needed, such as in farming to make animals grow faster. This constant exposure helps bacteria develop resistance more quickly. As a result, common infections can become harder and more expensive to treat, and medical procedures like surgery become riskier. To prevent this problem, it is important to use antibiotics only when prescribed by a doctor, complete the full course, and avoid using them unnecessarily in humans and animals.

Self-Medication

Taking them without a doctor's advice — is a major cause of antibiotic resistance. Many people use leftover antibiotics or buy them without a prescription to treat illnesses like colds or sore throats, which are usually caused by viruses. Since antibiotics don't work on viruses, this unnecessary use helps bacteria become stronger and resistant. Taking the wrong dose or stopping early also lets some bacteria survive and spread. To prevent this, antibiotics should only be used when prescribed by a doctor and the full course should always be finished

Use of Antibiotics in Agriculture

Using antibiotics in farm animals can contribute significantly to antibiotic resistance. On many farms, antibiotics are given to healthy animals to prevent disease or to promote faster growth. While this may seem helpful, it gives bacteria a chance to become stronger and resistant to these drugs. These resistant bacteria can then spread to humans through the food we eat, direct contact with animals, or even through the environment. This makes infections in people harder to treat. To reduce this risk, antibiotics should only be used in animals when prescribed by a veterinarian, and should always be paired with good hygiene and proper vaccination practices.

Poor Infection Control:

Poor infection control in hospitals, clinics, and communities helps resistant bacteria spread more easily. Practices like not washing hands properly, using unclean medical equipment, or overcrowding in healthcare facilities create the perfect conditions for these bacteria to move from person to person. When people become infected with resistant bacteria, doctors often need to use stronger, more powerful antibiotics, which can worsen resistance. Simple measures such as regular handwashing, thorough cleaning of equipment, and isolating sick patients can go a long way in preventing the spread of resistant bacteria.

Slow Development of New Antibiotics

Another major challenge is the slow development of new antibiotics. Creating new drugs is very expensive, and pharmaceutical companies often do not find it profitable. As a result, very few new antibiotics are being developed to replace those that are no longer effective. This shortage makes it even more important to use existing antibiotics responsibly and to support research for new treatments to keep infections manageable.

Mechanism of Bacterial Resistance

Bacteria are smart and can adapt quickly. When antibiotics are used, most bacteria die, but a few may survive because of small genetic changes. These survivors multiply and pass on their resistance, creating new generations of stronger bacteria.

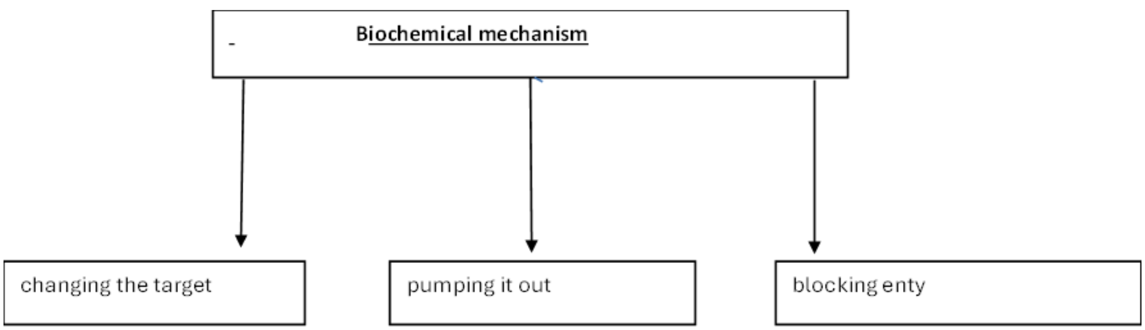
Genetic Mechanism

Bacteria can become resistant to antibiotics in a couple of ways. Sometimes their DNA changes naturally through mutations**,** which can help them survive even when antibiotics are used. They can also share genes with other bacteria, which makes resistance spread faster.

This can happen when bacteria touch each other, pick up DNA from their surroundings, or get genes through viruses that transfer DNA between bacteria.

Some bacteria carry plasmids**,** which are small pieces of DNA that can have several resistance genes at once, making them resistant to multiple antibiotics

These processes allow resistance to spread quickly, even between different types of bacteria. Understanding how bacteria share and change their genes is important to help stop antibiotic resistance and keep medicines working



Here's a detailed, humanized, and easy-to-read version of your points about bacterial resistance mechanisms, with each point expanded for clarity. I've kept the grammar simple and accessible:

1. Making Enzymes

Some bacteria produce special enzymes, such as β-lactamases, that can break down antibiotics before they have a chance to work. These enzymes essentially destroy the drug, rendering medicines like penicillin and other related antibiotics ineffective. This means that even if the medicine reaches the bacteria, it cannot kill them, making infections harder to control.

2. Changing the Target

Certain bacteria can alter the specific part of their cell or machinery that an antibiotic is meant to attack. For example, an antibiotic may be designed to bind to a bacterial protein to stop growth, but if the bacteria change that protein, the drug can no longer attach properly.

As a result, the antibiotic loses its effect, allowing the bacteria to survive and continue multiplying.

3. Pumping It Out

Some bacteria have tiny molecular "pumps" in their cell membranes that actively push antibiotics out of their cells.

These pumps reduce the concentration of the drug inside the bacteria, making it less effective.

This mechanism can affect multiple drugs at once, contributing to multidrug resistance**,** which makes infections much harder to treat with standard therapies.

4. Blocking Entry

Other bacteria prevent antibiotics from entering their cells in the first place.

They can modify their cell walls or membranes, reducing the number of openings that drugs can pass through.

If the antibiotic cannot get inside the bacterial cell, it cannot reach its target and fails to work. This strategy is especially important in certain gram-negative bacteria, which have naturally tough outer membranes.

5. Combining Tricks

Many bacteria do not rely on just one defense mechanism—they combine several at once

By using multiple strategies, bacteria become multidrug-resistant (MDR), making them extremely difficult to treat.

These bacteria can survive even in the presence of several different antibiotics, posing a serious challenge in hospitals and the community.

6. Forming Biofilms

Some bacteria form biofilms**,** which are protective layers made of sugars, proteins, and DNA. Biofilms act like a shield, protecting bacteria from antibiotics and the body's immune system. They are commonly seen in chronic infections, such as those on catheters, implants, or in the lungs of cystic fibrosis patients. Biofilms make infections persistent and much harder to treat, often requiring higher doses of drugs or long-term therapy.

Global Impact and Trends

The problem of antibiotic resistance is a serious global threat. According to the World Health Organization's Global Antimicrobial Resistance Surveillance System (GLASS), in 2023, about one in six lab-confirmed bacterial infections worldwide were resistant to at least one antibiotic.

Some of the most common bacteria are becoming especially hard to treat. For example:

Escherichia coli (E. coli) and Klebsiella pneumoniae. In bloodstream infections, around 36% of E. coli and 58% of K. pneumoniae were resistant to third-generation cephalosporins. In some countries, resistance in K. pneumoniae reached an alarming 80–100%

Staphylococcus aureus (MRSA): Around 12% of bloodstream infections were methicillin-resistant, with some areas reporting rates as high as 26%

The situation is even worse in low- and middle-income countries (LMICs). Regions with weaker laboratory systems and less surveillance often report much higher resistance levels. In some parts of Africa, for instance, more than 70% of E. coli and K. pneumoniae are resistant to third-generation cephalosporins.

Several factors make the problem worse in these areas:

Limited access to proper diagnostics. meaning doctors may have to prescribe antibiotics without knowing if they're really needed. Easy availability of over-the-counter antibiotics, often without a prescription.

There are fewer rules and controls around how antibiotics are dispensed. All of this helps resistant bacteria spread faster.

In short, antibiotic resistance is widespread, making standard treatments less effective—even our "last-resort" drugs.

Without urgent global action, the problem will continue to grow, putting millions of lives at risk and making once-treatable infections far more dangerous.

Impact of COVID 19 on antibiotics resistance

Antimicrobial resistance (AMR) happens when bacteria and other germs change over time and stop responding to the medicines used to kill them.

It was already a major global health problem even before COVID-19.

The COVID-19 pandemic disrupted healthcare systems in many ways. Hospitals focused mainly on COVID care, infection-control routines changed, elective (non-urgent) treatments were delayed, and patterns of antibiotic use also shifted.

Diagnostic services were often under heavy pressure.

These disruptions could make AMR worse, for example by increasing unnecessary antibiotic use or reducing proper monitoring. However, in some cases, lockdowns and reduced travel may have helped slow down the spread of resistant bacteria.

How COVID-19 May Have Affected Antimicrobial Resistance (AMR)

COVID-19 has influenced the rise and spread of antibiotic resistance in several ways. These effects are connected and often happened at the same time.

a) More Antibiotic Use

Even though COVID-19 is caused by a virus (not bacteria), many patients were given antibiotics "just in case."

The World Health Organization (WHO) found that while only about 8%of hospitalized COVID-19 patients actually had bacterial infections that needed antibiotics, around 75%still received them between 2020 and 2022. Using antibiotics when they're not needed—especially strong, broad-spectrum ones—creates pressure that helps resistant bacteria survive and spread.

b) Weakened Infection Control and Antibiotic Oversight

During the height of the pandemic, many hospitals were overwhelmed. Normal infection-control routines like handwashing checks, patient isolation, and monitoring of antibiotic use were often put on hold.

Patients with severe COVID-19 often needed long hospital stays, ventilators, and other medical devices, which increased the chance of catching hospital-acquired infections, including those caused by resistant bacteria.

c) Problems with Diagnosis and Delayed Testing

It's hard to tell the difference between a bacterial infection and severe COVID-19 based on symptoms alone. Because of this, doctors often prescribed antibiotics "just to be safe."

In some places, lab resources were focused on COVID-19 testing, which meant delays in identifying bacterial infections or testing which antibiotics would work best. That sometimes led to less-targeted antibiotic use.

d) Changes in How Infections Spread

On the positive side, measures like lockdowns, social distancing, and reduced travel helped lower the spread of some drug-resistant bacteria in the community. But inside hospitals, crowded ICUs and increased use of medical devices made it easier for multi-drug-resistant organisms (MDROs) to spread among patients.

Evidence on Antibiotic Resistance During the COVID-19 Pandemic

Overall, the evidence points to a worrying rise in antibiotic resistance during the COVID-19 pandemic, though the effects varied across regions, hospitals, and types of bacteria.

Reviews and meta-analyses show notable increases in multidrug-resistant organisms, including carbapenem-resistant Acinetobacter baumannii, carbapenem-resistant Enterobacteriaceae, and MRSA .

Hospital data suggest that the pandemic led to higher use of broad-spectrum antibiotics and increased resistance in species such as A. baumannii, Pseudomonas aeruginosa, and Klebsiella pneumoniae In ICUs, patients with COVID-19 were more than three times as likely to have multidrug-resistant infections compared with the pre-pandemic period .

At the same time, some studies found little change in overall resistance, showing that the impact of the pandemic was not uniform and depended on factors like local healthcare practices, pathogen types, and the strength of antibiotic stewardship programs

The Role of Pharmacist

Pharmacists play a crucial role in the fight against antibiotic resistance, and they do it in several important ways.

Guiding the Right Use of Antibiotics:

Pharmacists lead antimicrobial stewardship programs, which are systems designed to make sure antibiotics are used correctly. They help ensure antibiotics are only prescribed when truly needed, at the right dose, and for the right length of time. Research shows that pharmacist-led programs improve prescribing habits, reduce unnecessary use of broad-spectrum antibiotics, shorten treatment courses when possible, and even save money for the healthcare system. In other words, pharmacists help make sure antibiotics are being used smartly and safely.

Educating Patients:

Pharmacists often have one of the last opportunities to speak with patients before they start their antibiotic treatment. This gives them a unique chance to explain how to use antibiotics safely. They teach patients why it's important to finish the entire course, never save leftover pills, avoid sharing antibiotics with others, and understand that antibiotics don't work for viral infections like colds or the flu. By giving clear, practical advice, pharmacists help patients take antibiotics in a way that actually works—and helps prevent resistance.

Monitoring and Reporting:

Pharmacists are constantly reviewing prescriptions and tracking how antibiotics are being used in their communities or hospitals. They can spot misuse or overuse early and work directly with doctors, nurses, and other healthcare professionals to make better choices. Their oversight helps prevent small mistakes from turning into bigger problems, like infections that are harder to treat.

Public Health and Policy Work:

Beyond the pharmacy counter, pharmacists contribute to the bigger picture of public health. They take part in awareness campaigns to educate the community about antibiotic resistance, support stricter regulations on how antibiotics are sold, and help shape healthcare policies aimed at reducing misuse. This means their impact isn't just on individual patients—it's on entire communities.

By combining these efforts—guiding prescriptions, educating patients, monitoring use, and influencing policy—pharmacists help ensure antibiotics remain effective. Their work today not only treats patients safely but also protects future generations from dangerous, drug-resistant infections.

New and Emerging Approach

New Antibiotics and Drug Combinations:

Scientists are working on new antibiotics and also mixing existing drugs in smart ways to fight bacteria that have become resistant. For example, β-lactamase inhibitors are medicines that block the bacterial enzymes that normally destroy antibiotics like penicillin. This lets older antibiotics work again. Researchers are also creating completely new types of antibiotics that attack bacteria in different ways, making it harder for bacteria to become resistant.

Bacteriophage Therapy:

Bacteriophages are viruses that specifically attack harmful bacteria. Unlike antibiotics, they don't harm the good bacteria in your body. They're being tested for hard-to-treat infections, chronic wounds, and bacteria that form protective layers called biofilms. Early studies show they usually have very few side effects.

Antimicrobial Peptides:

These are tiny proteins found in many living things, including humans, that can poke holes in bacterial cells and kill them. Because they attack essential parts of bacteria, it's harder for bacteria to develop resistance.

Nanotechnology:

Nanoparticles are super tiny particles that can deliver antibiotics straight to the infection site—even into tissues or bacterial layers that are usually hard to reach. This makes the treatment stronger, reduces side effects, and can help fight resistant bacteria.

CRISPR-based Therapies:

Scientists are experimenting with CRISPR, a gene-editing tool, to target and switch off the genes that make bacteria resistant. It's still in the early stages, but it could help bacteria respond to antibiotics again.

Probiotics:

Using good bacteria can keep your gut healthy, stop harmful bacteria from overgrowing, and even reduce the need for antibiotics in some cases.

Vaccines:

Vaccines that prevent bacterial infections mean fewer people get sick, which lowers the need for antibiotics and slows down resistance. Vaccines for pneumococcus, Haemophilus influenzae, and Salmonella have already reduced antibiotic use in many places.

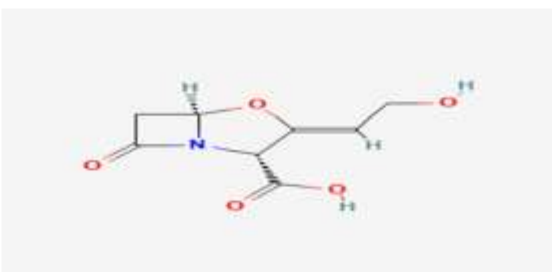
Together, these approaches—new drugs, alternative therapies, and preventive measures—give us multiple ways to fight resistant bacteria and keep antibiotics effective for the future.

Resistance Type	Key Example Organisms	Typical First-Line Failures	Alternative / Last-Line Remedies
MRSA	*S. aureus*	β-lactams	Vancomycin, Linezolid
VRE	*Enterococcus spp.*	Vancomycin	Daptomycin, Linezolid
ESBL	*E. coli*, *Klebsiella spp.*	Penicillins, Cephalosporins	Carbapenems
Carbapenem-Resistant (CRE/CRAB)	*Klebsiella, Acinetobacter*	Carbapenems	Avibactam / Vaborbactam combos, Colistin
MDR / XDR-TB	*M. tuberculosis*	Isoniazid, Rifampicin	Bedaquiline, Linezolid, Delamanid
XDR Typhoid	*S. typhi*	Older antibiotics	Azithromycin, Carbapenems
MDR Gonorrhea	*N. gonorrhoeae*	Penicillin, FQs	Ceftriaxone + Azithromycin

Drugs used to reduce bacterial resistance

B-Lactamase inhibitors

1) **Clavulanic acid**



It is a B-lactamase inhibitor class of drug. It is used in combination with amoxycillin to treat certain bacterial infections. This combination is used in urinary tract infection, lower respiratory infection, sinusitis, otitis media, and some skin infection. Clavulanic acid is always used in combination. It has a weak broad spectrum of antibacterial activity. They have an affinity for B-lactamase and serve as potent irreversible inhibitors of many B-lactamase produced by gram + and gram – bacteria.

Clavulanic acid has B-lactam ring which binds to the beta-lactamase active site and then inactivates the enzyme and enhances antibacterial effect. It permanently inactivate the enzyme.

2) **Sulbactam**

Sulbactam is a medicine that helps other antibiotics work better. Some bacteria can produce special enzymes that destroy antibiotics like penicillin and make them useless. Sulbactam blocks these enzymes, stopping the bacteria from breaking down the antibiotic. On its own, sulbactam doesn't kill many bacteria (except a few types, like *Acinetobacter*), but when it's combined with other antibiotics, it makes them stronger and more effective against resistant infections. These combinations are used to treat problems like lung infections, urinary tract infections, skin and soft tissue infections, abdominal infections, and more. Sulbactam is usually given as an injection into a vein or muscle. Most people tolerate it well, but some may experience mild side effects like pain where the injection was given, stomach upset, rash, or allergic reactions. Doctors may adjust the dose if someone has kidney problems. In short, sulbactam is a “helper” medicine that protects antibiotics so they can do their job and fight bacteria more effectively.

3) **Tazobactum**

Tazobactum is a medicine that helps certain antibiotics work better, especially when combined with drugs like piperacillin. Some bacteria make enzymes called β-lactamases that can break down antibiotics, making them less effective. Tazobactam blocks these enzymes, so the antibiotic can kill the bacteria properly. On its own, tazobactam doesn’t really fight infections, but when used with a β-lactam antibiotic, it can fight a wider range of bacteria, including many resistant ones. It is often used to treat serious infections, such as complicated belly infections, hospital-acquired pneumonia, and urinary tract infections. Most people tolerate it well, though it can sometimes cause side effects like allergic reactions, stomach problems, or changes in liver tests. Combining piperacillin with tazobactam has become very important for treating infections caused by resistant bacteria, making it a key tool in modern medicine

CHALLENGES

Fighting antibiotic resistance is a big challenge that needs everyone—governments, healthcare workers, and communities—to work together. There are several problems that make it hard. Many people, especially in poorer areas, don’t have easy access to good healthcare or proper tests, so antibiotics are often used incorrectly. Tracking how antibiotics are used in these areas is also difficult, which lets resistant bacteria spread. Drug companies have little motivation to make new antibiotics because it is expensive and not very profitable. On top of that, many people don’t fully understand how to use antibiotics properly, like finishing the full course or avoiding them for viral infections. To tackle these issues, pharmacists should play a bigger role in healthcare teams, education on proper antibiotic use should be improved, and rules on antibiotic use need to be enforced. By working together and staying committed, we can slow down resistance and protect everyone’s health.

CONCLUSION

Antibiotic resistance is not just a problem for doctors or hospitals—it affects everyone. Pharmacists have an important role in fighting it because they know a lot about medicines and how to use them safely. They can guide patients to take antibiotics the right way, teach people about the risks of misuse, and encourage habits that stop resistant bacteria from spreading. Pharmacists also help make sure antibiotics are only used when really needed and that the full course is completed. They can support programs in hospitals and clinics that monitor and manage antibiotic use. Everyone can help by learning how to use antibiotics properly, avoiding self-medication, and supporting research for new treatments. By taking action now, we can protect these life-saving medicines and keep them working for future generations

REFERENCES

1. World Health Organization. Global Action Plan on Antimicrobial Resistance. WHO; 2020.
2. Centers for Disease Control and Prevention. Antibiotic Resistance Threats in the United States. CDC; 2019.
3. Ventola CL. “The Antibiotic Resistance Crisis.” Pharmacy and Therapeutics. 2015;40(4):277–283.
4. Laxminarayan R, et al. “Antibiotic Resistance—The Need for Global Solutions.”

The Lancet Infectious Diseases. 2013;13(12):1057–1098.

5. Pulcini C, et al. “Role of the Pharmacist in Antimicrobial Stewardship.” JAC-Antimicrobial Resistance. 2019;1(1):dlz022.
6. https://www.ncbi.nlm.nih.gov/books/NBK545273https://www.youtube.com/watch?v=2NQLUbaZSgc
7. Van Boeckel, T. P., et al. (2015). “Global trends in antimicrobial use in animals.” Science, 347(6229), 564–567.
8. Alhomoud, F., et al. (2018). “Self-medication and antibiotic resistance: A global problem.” International Journal of Clinical Pharmacy, 40(1), 48–52.
9. O’Neill, J. (2016). Tackling Drug-Resistant Infections Globally: Final Report and Recommendations.
10. Munita, J. M., & Arias, C. A. (2016). “Mechanisms of antibiotic resistance.” Microbiology Spectrum, 4(2).Cidrap.umn.edu
11. Compiled from WHO (2017), CDC (2022), and major clinical reviews (Bassetti et al., 2023; Tacconelli et al., 2018; Karaiskos & Giamarellou, 2020).
12. Rawson TM, Moore LSP, Castro-Sanchez E, Charani E, Davies F, Satta G, Ellington MJ, Holmes AH. The potential impact of the COVID-19 pandemic on antimicrobial resistance and antibiotic stewardship. Journal of Antimicrobial Chemotherapy. 2020;75(12):3413–3416.
13. Rawson, T.M., Moore, L.S.P., Zhu, N., Ranganathan, L., Skolimowska, K., et al. (2022). “Antibiotic ResistanceduringCOVID-19: ASystematicReview.”International Journal of Environmental Research and Public Health, 19(19), 11931.
14. Langford, B., Sweitzer, B., Li, D., Jiang, Y., et al. (2023). “Antibiotic resistance associated with the COVID-19 pandemic: a systematic review and meta-analysis.” Journal of Infection, (advance online publication).
15. Kanj, S. S., & Rodrigues, C. (2022). “Beyond the Pandemic: The Value of Antimicrobial Stewardship.” Frontiers in Public Health, 10, 902835

HOW TO CITE: Aniket Raje Ghadage, Onkar Korade, Shubham Bansode, Dr. R. R. Bendgude, A Review on Antibiotics Resistance : A Growing Threat, Int. J. of Pharm. Sci., 2025, Vol 3, Issue 11, 1671-1680. https://doi.org/10.5281/zenodo.17580636