iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 **Issue:** XII **Month of publication:** December 2024

DOI: https://doi.org/10.22214/ijraset.2024.65767

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue XII Dec 2024- Available at www.ijraset.com

Global Impact of Antibiotic Resistance

Prathmesh Rajendra Lonare[1], Chinmay Rajendra Kapile[2], Siddharth Shrikant Chandak[3], Sanket Digambar Sonawane[4]

Abstract: ***Antibiotic resistance (AMR) is a growing global health crisis that poses a significant threat to public health, economies, and healthcare systems worldwide. The emergence of resistant bacteria, fungi, and viruses has been driven by the overuse and misuse of antibiotics in human medicine, agriculture, and animal farming. AMR reduces the effectiveness of treatment options, leading to longer hospital stays, increased medical costs, and higher mortality rates. Furthermore, infections caused by resistant pathogens are becoming harder to treat, complicating efforts to combat common diseases such as pneumonia, tuberculosis, and urinary tract infections. The global impact of antibiotic resistance is not limited to individual countries; it is a cross-border issue that requires international cooperation and a multifaceted approach, involving surveillance, regulation, and public awareness campaigns. Low- and middle-income countries, where access to antibiotics is often unregulated, face the highest risks. In addition to human health, the economic toll of AMR is severe, with global estimates suggesting that antibiotic resistance could lead to a reduction in global GDP by up to 3.5% by 2050. Combating AMR requires urgent action from governments, healthcare providers, pharmaceutical companies, and the public to implement better stewardship practices, invest in research and development of new antibiotics, and adopt preventative measures. A united global response is essential to mitigate the long-term consequences of this silent pandemic.***

Keywords: Antibiotic resistance, global health, healthcare systems, public health, economic impact.

I. INTRODUCTION

Antibiotic resistance (AMR) has become one of the most serious threats to global health. It occurs when bacteria, viruses, fungi, and parasites develop the ability to resist the effects of medicines that once killed them or stopped their growth. This means that common infections that were once easily treatable with antibiotics are becoming harder, or even impossible, to treat. AMR is a natural process, but human activities, such as overusing antibiotics in hospitals, farms, and homes, have accelerated the development of resistance.

The consequences of antibiotic resistance are far-reaching. Infections that were previously controlled with routine medications are now lasting longer, leading to more severe illness and an increased number of deaths. For example, conditions like pneumonia, urinary tract infections, and tuberculosis are becoming harder to treat, with some resistant infections leading to death if no effective treatment is available. In addition to health impacts, AMR also burdens healthcare systems and economies. Longer hospital stays, more intensive care, and the need for more expensive drugs increase medical costs, making it harder for countries to manage healthcare spending.

Antibiotic resistance is a global problem, affecting both developed and developing countries, but poorer nations face the greatest challenges due to weaker healthcare systems and limited access to quality medications. This growing problem requires immediate action at the international level. Governments, healthcare providers, researchers, and individuals all need to work together to reduce antibiotic misuse, improve infection prevention, and support the development of new antibiotics to tackle this serious issue before it worsens.

II. AZITHROMYCIN AND ITS RAMPANT USE

Azithromycin is a widely used antibiotic that belongs to the class of drugs called macrolides. It is commonly prescribed to treat a variety of bacterial infections, including respiratory infections like pneumonia, bronchitis, and sinusitis, as well as sexually transmitted diseases (STDs) such as chlamydia. Due to its broad spectrum of activity and relatively low side-effect profile, azithromycin has become one of the most commonly prescribed antibiotics worldwide.

However, the rampant and often inappropriate use of azithromycin has contributed to the growing problem of antibiotic resistance. One key issue is its frequent overuse in both healthcare settings and communities. Many individuals seek antibiotics for viral infections, like the common cold or flu, where antibiotics like azithromycin are ineffective. Additionally, azithromycin is sometimes prescribed as a "first-line" treatment for mild conditions that could resolve on their own without the need for antibiotics. This overuse accelerates the development of antibiotic resistance in the bacteria exposed to the drug, leading to strains that are resistant to azithromycin and other antibiotics.

Another concern is its use in agriculture, where it is sometimes administered to livestock to prevent infections or promote growth. This practice can contribute to the spread of antibiotic resistance in bacteria that can affect humans. The widespread availability of azithromycin without a prescription in some countries further exacerbates the problem, as individuals self-medicate without proper medical supervision, leading to misuse and resistance.

Azithromycin resistance, especially in bacteria like *Neisseria gonorrhoeae* (which causes gonorrhea), has already been reported, reducing the drug's effectiveness in treating these infections. The rampant use of azithromycin, combined with the lack of proper regulation, underscores the urgent need for better stewardship of antibiotics and increased public awareness about the risks of overuse.

A. Azithromycin's Place in Modern Medical Practice and Guidelines

Azithromycin is a broad-spectrum antibiotic belonging to the macrolide class. It is widely used in modern medical practice due to its effectiveness against a range of bacterial infections, its convenient dosing schedule, and relatively low side-effect profile. Azithromycin works by inhibiting bacterial protein synthesis, making it an effective treatment for both gram-positive and gram-negative bacteria.

1) *Common Indications and Clinical Use:* Azithromycin is commonly prescribed to treat respiratory infections such as *pneumonia*, *bronchitis*, and *sinusitis*. It is also used for treating *otitis media* (middle ear infections), *pharyngitis* (sore throat), and *tonsillitis*. In addition, Azithromycin is effective in treating sexually transmitted infections (STIs) like *chlamydia* and *gonorrhea*. Its ability to treat a wide range of infections makes it a key antibiotic in outpatient settings, particularly for patients who may not have access to more specialized care.

2) *Advantages Over Other Antibiotics:* Azithromycin has several advantages that contribute to its widespread use in medical practice:

- Short Treatment Duration: Azithromycin typically requires a short course of treatment (usually 3-5 days), which improves patient compliance.
- Convenient Dosing: Unlike many other antibiotics, Azithromycin is often dosed once daily, making it easier for patients to follow their treatment regimen.
- Good Tissue Penetration: Azithromycin has good tissue penetration, which is crucial for treating infections in various body tissues, such as the lungs or sinuses.

3) *Use in Specific Populations:* Azithromycin is often favored in special populations, such as those with penicillin allergies, due to its relatively safe profile. It is also widely used in pediatric care to treat common infections like *ear infections* and *streptococcal throat infections*. Additionally, it is often the antibiotic of choice in treating certain atypical bacterial infections, like *Mycoplasma pneumoniae* and *Chlamydia trachomatis*.

4) *Azithromycin in Clinical Guidelines:* Azithromycin is included in various national and international clinical guidelines for the management of respiratory infections, STIs, and other bacterial infections. For example:

- In the *United States*, the CDC recommends Azithromycin as a first-line treatment for uncomplicated gonorrhea (often in combination with another antibiotic to prevent resistance).
- The *World Health Organization* (WHO) includes Azithromycin in their list of essential medicines due to its broad efficacy against common infections.
- For *community-acquired pneumonia*, Azithromycin is often recommended as part of empiric therapy, especially in areas with high rates of atypical pathogens.

5) *Controversial Uses and Risks:* While Azithromycin remains a cornerstone in treating infections, its use has been under scrutiny due to the growing concerns of antibiotic resistance. For example, it has been used inappropriately for viral infections such as the common cold or flu, where it provides no benefit. Furthermore, its use in combination with other antibiotics to treat certain infections, such as respiratory or STIs, must be carefully considered to avoid unnecessary overuse and resistance development. In some countries, unregulated use in agricultural settings (such as for livestock) also contributes to the emergence of resistant bacteria.

6) *Emerging Role in COVID-19 Treatment:* During the COVID-19 pandemic, Azithromycin was widely investigated as a potential treatment for the virus due to its anti-inflammatory and antibacterial properties. However, research has largely shown limited benefit in treating COVID-19 itself, and its use for this purpose is now generally discouraged, unless there is a secondary bacterial infection. This highlights the need for careful adherence to established guidelines and the importance of evidence-based prescribing.

B. Conclusion

Azithromycin continues to play a critical role in modern medical practice, especially for treating bacterial infections in the respiratory system and sexually transmitted diseases. However, its widespread and sometimes inappropriate use has led to concerns about the development of resistance. Adhering to clinical guidelines, promoting stewardship, and educating both healthcare professionals and patients about responsible antibiotic use are essential steps in maintaining Azithromycin's effectiveness in the long term.

III. AZITHROMYCIN RESISTANCE

Azithromycin, a macrolide antibiotic, is commonly used to treat various bacterial infections, including respiratory tract infections, sexually transmitted infections, and certain gastrointestinal infections. Resistance to azithromycin has emerged as a significant public health concern due to its extensive use, especially in treating *Streptococcus pneumoniae*, *Neisseria gonorrhoeae*, and *Mycoplasma genitalium*.

A. Mechanisms of Resistance

1) Efflux Pumps

- Some bacteria acquire genes that encode efflux pumps, actively transporting azithromycin out of the cell, reducing its intracellular concentration.
- Example: *mef(A)* gene in *Streptococcus pneumoniae*.

2) Target Site Modification

- Mutations in the 23S rRNA gene of the bacterial ribosome or the acquisition of methylase enzymes encoded by the *erm* gene family lead to reduced azithromycin binding.
- Example: *erm(B)* gene in *S. pneumoniae* and *Mycoplasma genitalium.*

3) Enzymatic Degradation

- Some bacteria produce enzymes that hydrolyze azithromycin, rendering it inactive.

4) Gene Mutations

- Mutations in genes like *parC* and *gyrA* in *N. gonorrhoeae* also confer resistance.

B. Clinical Impact

1) Treatment Failure: Resistance can result in treatment failure in infections like gonorrhea, where azithromycin is part of dual therapy.
2) Spread of Resistance: Resistant bacteria can spread within communities, complicating treatment strategies.
3) Increased Healthcare Costs: Alternatives to azithromycin are often more expensive or associated with more side effects.

C. Factors Contributing to Resistance

1) Overuse and Misuse: Excessive and inappropriate use of azithromycin in humans and livestock accelerates resistance.
2) Incomplete Treatment Courses: Patients not completing prescribed doses contribute to the survival of partially resistant bacteria.
3) Horizontal Gene Transfer: Bacteria can acquire resistance genes from other resistant strains.

D. Prevention and Management

1) Antimicrobial Stewardship

- Promote rational use of azithromycin, restricting use to cases where it is truly needed.
- Implement prescription guidelines.

2) Surveillance Programs

- Monitor resistance patterns globally to guide treatment protocols.

3) Alternative Therapies
- Research new antibiotics or combinations of existing drugs.
- Use non-macrolide antibiotics when resistance is suspected.

4) Public Education
- Educate healthcare providers and the public about the risks of antibiotic misuse.

5) Infection Control
- Implement infection prevention measures in healthcare and community settings to limit the spread of resistant bacteria.

E. Research Focus

1) Investigating new antibiotics targeting resistant strains.
2) Developing rapid diagnostic tests to identify resistant pathogens.
3) Exploring phage therapy and other non-antibiotic approaches.

Addressing azithromycin resistance requires a multi-faceted approach involving healthcare providers, policymakers, researchers, and the public to mitigate its spread and impact effectively.

IV. HOW TO AVOID AZITHROMYCIN RESISTANCE

Avoiding antibiotic resistance, including azithromycin resistance, requires a combination of responsible practices, public awareness, and proactive healthcare measures. Here's how to minimize the risk:

A. Use Antibiotics Responsibly

1) Prescribe Only When Necessary
- Ensure azithromycin is prescribed only for infections confirmed or strongly suspected to be bacterial and sensitive to macrolides.
- Avoid prescribing for viral infections (e.g., colds, flu).

2) Follow Proper Dosage and Duration
- Complete the full course of antibiotics as prescribed, even if symptoms improve early.
- Avoid skipping doses to prevent subtherapeutic levels that encourage resistance.

B. Diagnostic Stewardship

1) Accurate Diagnosis
- Use diagnostic tools to confirm the causative organism before prescribing antibiotics.
- Prefer culture and sensitivity tests to determine the susceptibility of the bacteria to azithromycin.

2) Rapid Diagnostic Tests
- Invest in tools to identify resistant strains quickly, ensuring targeted therapy.

C. Limit Over-the-Counter Antibiotic Access

1) Prohibit the sale of antibiotics like azithromycin without a valid prescription.
2) Educate pharmacists and regulate dispensing practices.

D. Promote Alternative Treatments

1) Use non-antibiotic treatments or narrow-spectrum antibiotics when possible.
2) Encourage vaccinations (e.g., pneumococcal, influenza) to reduce infections that may otherwise require antibiotics.

E. Prevent Infections

1) Personal Hygiene
- Regular handwashing with soap and water.
- Safe food preparation and clean drinking water access.

2) Public Health Measures
- Implement infection control in healthcare settings.
- Promote safe sexual practices to prevent sexually transmitted infections (e.g., resistant *N. gonorrhoeae*).

F. Educate Healthcare Professionals and the Public

1) Train healthcare workers to identify and manage bacterial infections appropriately.
2) Run awareness campaigns to inform the public about the risks of antibiotic misuse.

G. Implement Antimicrobial Stewardship Programs (ASP)

1) Introduce hospital-based and community-level programs to oversee antibiotic prescribing and usage.
2) Audit and provide feedback to prescribers on their antibiotic use.

H. Monitor Resistance Patterns

1) Establish surveillance programs to track azithromycin resistance trends.
2) Share data among healthcare institutions to adjust treatment guidelines.

I. Research and Development

1) Invest in the development of new antibiotics to outpace resistance.
2) Explore alternative therapies, such as bacteriophage therapy or probiotics.

J. Global Cooperation

1) Encourage international collaboration to address resistance in a unified manner.
2) Limit the use of antibiotics in agriculture to prevent cross-species resistance.

By combining these strategies, individuals and healthcare systems can significantly reduce the development and spread of azithromycin resistance.

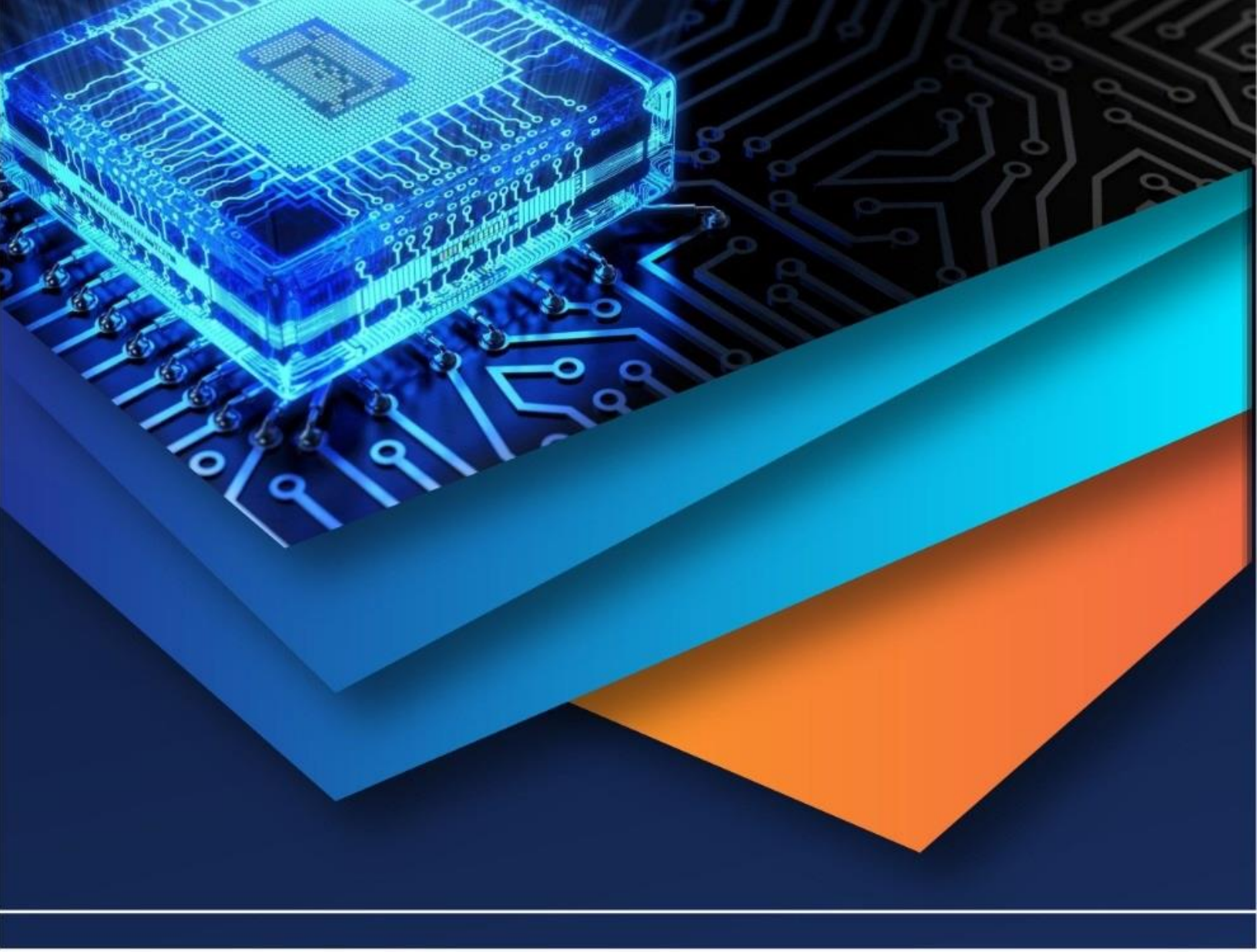
V. CONCLUSION

Azithromycin resistance poses a significant challenge to global public health, threatening the efficacy of one of the most widely used antibiotics. Preventing resistance requires a multifaceted approach that combines responsible antibiotic use, accurate diagnostics, robust infection prevention measures, and public awareness. Healthcare providers must prescribe antibiotics judiciously, and patients must adhere to prescribed regimens. Simultaneously, investments in surveillance, education, and research are critical to staying ahead of evolving resistance patterns. By fostering collaboration between individuals, healthcare systems, and policymakers, we can preserve the effectiveness of azithromycin and other antibiotics for future generations.

REFRENCES

[1] Taylor HR, Burton MJ, Haddad D, West S, Wright H. Trachoma. Lancet 2014; 384:2142–52. [DOI] [PubMed] [Google Scholar]
[2] Evans JR, Solomon AW. Antibiotics for trachoma. Cochrane Database Syst Rev 2011:Cd001860. [DOI] [PubMed] [Google Scholar]
[3] Porco TC, Gebre T, Ayele B, et al. . Effect of mass distribution of azithromycin for trachoma control on overall mortality in Ethiopian children: a randomized trial. JAMA 2009; 302:962–8. [DOI] [PubMed] [Google Scholar]
[4] Keenan JD, Bailey RL, West SK, et al. ; MORDOR Study Group Azithromycin to reduce childhood mortality in sub-Saharan Africa. N Engl J Med 2018; 378:1583–92. [DOI] [PMC free article] [PubMed] [Google Scholar]
[5] Keenan JD, Arzika AM, Maliki R, et al. . Longer-term assessment of azithromycin for reducing childhood mortality in Africa. N Engl J Med 2019; 380:2207–14. [DOI] [PMC free article] [PubMed] [Google Scholar]
[6] Leclercq R. Mechanisms of resistance to macrolides and lincosamides: nature of the resistance elements and their clinical implications. Clin Infect Dis 2002; 34:482–92. [DOI] [PubMed] [Google Scholar]
[7] Wilson DN. Ribosome-targeting antibiotics and mechanisms of bacterial resistance. Nat Rev Microbiol 2014; 12:35–48. [DOI] [PubMed] [Google Scholar]
[8] Long S. Mechanisms and detection of antimicrobial resistance. In: Principles and Practice of Pediatric Infectious Diseases. 5th ed Philadelphia, PA: : Elsevier, 2018:1472–3. [Google Scholar]
[9] Klaassen CH, Mouton JW. Molecular detection of the macrolide efflux gene: to discriminate or not to discriminate between mef(A) and mef(E). Antimicrob Agents Chemother 2005; 49:1271–8. [DOI] [PMC free article] [PubMed] [Google Scholar]
[10] Reynolds E, Ross JI, Cove JH. Msr(A) and related macrolide/streptogramin resistance determinants: incomplete transporters? Int J Antimicrob Agents 2003; 22:228–36. [DOI] [PubMed] [Google Scholar]
[11] Sutcliffe J, Tait-Kamradt A, Wondrack L. Streptococcus pneumoniae and Streptococcus pyogenes resistant to macrolides but sensitive to clindamycin: a common resistance pattern mediated by an efflux system. Antimicrob Agents Chemother 1996; 40:1817–24. [DOI] [PMC free article] [PubMed] [Google Scholar]
[12] Hanage WP, Fraser C, Tang J, Connor TR, Corander J. Hyper-recombination, diversity, and antibiotic resistance in pneumococcus. Science 2009; 324:1454–7. [DOI] [PubMed] [Google Scholar]

[13] Malhotra-Kumar S, Lammens C, Coenen S, Van Herck K, Goossens H. Effect of azithromycin and clarithromycin therapy on pharyngeal carriage of macrolide-resistant streptococci in healthy volunteers: a randomised, double-blind, placebo-controlled study. Lancet 2007; 369:482–90. [DOI] [PubMed] [Google Scholar]
[14] Stokes HW, Gillings MR. Gene flow, mobile genetic elements and the recruitment of antibiotic resistance genes into gram-negative pathogens. FEMS Microbiol Rev 2011; 35:790–819. [DOI] [PubMed] [Google Scholar]
[15] Gomes C, Martínez-Puchol S, Palma N, et al. . Macrolide resistance mechanisms in Enterobacteriaceae: focus on azithromycin. Crit Rev Microbiol 2017; 43:1–30. [DOI] [PubMed] [Google Scholar]
[16] Sheppard AE, Stoesser N, Wilson DJ, et al. ; Modernising Medical Microbiology (MMM) Informatics Group Nested Russian doll-like genetic mobility drives rapid dissemination of the carbapenem resistance gene blaKPC. Antimicrob Agents Chemother 2016; 60:3767–78. [DOI] [PMC free article] [PubMed] [Google Scholar]
[17] Paterson DL. Resistance in gram-negative bacteria: Enterobacteriaceae. Am J Med 2006; 119(6 Suppl 1):S20–8; discussion S62-70. [DOI] [PubMed] [Google Scholar]
[18] Peters DH, Friedel HA, McTavish D. Azithromycin: a review of its antimicrobial activity, pharmacokinetic properties and clinical efficacy. Drugs 1992; 44:750–99. [DOI] [PubMed] [Google Scholar]
[19] Doan T, Arzika AM, Hinterwirth A, et al. ; MORDOR Study Group Macrolide resistance in MORDOR I—a cluster-randomized trial in Niger. N Engl J Med 2019; 380:2271–3. [DOI] [PMC free article] [PubMed] [Google Scholar]
[20] Yassour M, Vatanen T, Siljander H, et al. . Natural history of the infant gut microbiome and impact of antibiotic treatment on bacterial strain diversity and stability. Sci Trans Med 2016; 8:343ra381. [DOI] [PMC free article] [PubMed] [Google Scholar]
[21] Korpela K, Salonen A, Virta LJ, et al. . Intestinal microbiome is related to lifetime antibiotic use in Finnish pre-school children. Nat Commun 2016; 7:10410. [DOI] [PMC free article] [PubMed] [Google Scholar]
[22] Bokulich NA, Chung J, Battaglia T, et al. . Antibiotics, birth mode, and diet shape microbiome maturation during early life. Sci Trans Med 2016; 8:343ra382. [DOI] [PMC free article] [PubMed] [Google Scholar]
[23] Shaw LP, Bassam H, Barnes CP, Walker AS, Klein N, Balloux F. Modelling microbiome recovery after antibiotics using a stability landscape framework. ISME J 2019; 13:1845–56. [DOI] [PMC free article] [PubMed] [Google Scholar]
[24] Wei S, Mortensen MS, Stokholm J, et al. . Short- and long-term impacts of azithromycin treatment on the gut microbiota in children: a double-blind, randomized, placebo-controlled trial. EBioMedicine 2018; 38:265–72. [DOI] [PMC free article] [PubMed] [Google Scholar]
[25] Francino MP. Antibiotics and the human gut microbiome: dysbioses and accumulation of resistances. Front Microbiol 2015; 6:1543. [DOI] [PMC free article] [PubMed] [Google Scholar]
[26] O'Brien KS, Emerson P, Hooper PJ, et al. . Antimicrobial resistance following mass azithromycin distribution for trachoma: a systematic review. Lancet Infect Dis 2019; 19:e14–25. [DOI] [PubMed] [Google Scholar]
[27] Skalet AH, Cevallos V, Ayele B, et al. . Antibiotic selection pressure and macrolide resistance in nasopharyngeal Streptococcus pneumoniae: a cluster-randomized clinical trial. PLoS Med 2010; 7:e1000377. [DOI] [PMC free article] [PubMed] [Google Scholar]
[28] Keenan JD, Chin SA, Amza A, et al. ; Rapid Elimination of Trachoma (PRET) Study Group The effect of antibiotic selection pressure on the nasopharyngeal macrolide resistome: a cluster-randomized trial. Clin Infect Dis 2018; 67:1736–42. [DOI] [PubMed] [Google Scholar]
[29] Keenan JD, Klugman KP, McGee L, et al. . Evidence for clonal expansion after antibiotic selection pressure: pneumococcal multilocus sequence types before and after mass azithromycin treatments. J Infect Dis 2015; 211:988–94. [DOI] [PMC free article] [PubMed] [Google Scholar]
[30] Bojang E, Jafali J, Perreten V, et al. . Short-term increase in prevalence of nasopharyngeal carriage of macrolide-resistant Staphylococcus aureus following mass drug administration with azithromycin for trachoma control. BMC Microbiol 2017; 17:75. [DOI] [PMC free article] [PubMed] [Google Scholar]



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY