Int.J.Curr.Microbiol.App.Sci (2026) *15*(1): 121-126

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 15 Number 1 (2026)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2026.1501.014

Antimicrobial Resistance Surveillance: An Epidemiological Case Study from Nashik City, Maharashtra, India

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Keywords

Antibiotic resistance, broad-spectrum antibiotics, *Escherichia coli*, *Staphylococcus*

Article Info

Received:
19 November 2025
Accepted:
26 December 2025
Available Online:
10 January 2026

A B S T R A C T

Antimicrobial resistance poses a critical public health threat, especially in regions with high antibiotic usage. This study examines antibiotic prescription practices and resistance profiles in Nashik City, Maharashtra. A mixed-methods approach combining a survey of 228 healthcare practitioners with microbiological analysis of clinical samples revealed concerning patterns of antibiotic misuse. Broad-spectrum antibiotics were commonly prescribed empirically as first-line therapy, frequently in the absence of diagnostic testing. Correspondingly, high resistance rates were observed among key pathogens—72% of *Staphylococcus* isolates were resistant to penicillin and 92% of *Escherichia coli* isolates to cephalosporins. Although post-intervention data suggested improved awareness among practitioners regarding appropriate antibiotic use, resistance levels remained elevated. These findings emphasize the urgent need for sustained educational initiatives, enhanced diagnostic support, and stricter oversight of antibiotic dispensing to combat the rising threat of antibiotic resistance in Nashik City.

Introduction

Antibiotic resistance is a critical global health issue that threatens the efficacy of life-saving antibiotics used to treat bacterial infections. It arises when bacteria adapt in response to the use of antibiotics, making infections harder to treat and increasing the risk of disease spread, severe illness, and death (WHO, 2020). Globally, approximately 700,000 deaths annually are attributed to antibiotic resistance, and this number is projected to rise to 10 million deaths per year by 2050 if current trends continue (O'Neill, 2016). The overuse and misuse of antibiotics are recognized as major drivers of this phenomenon, with the World Health Organization (WHO) identifying antimicrobial resistance as one of the top ten global public health threats.

In India, antibiotic resistance is a significant and growing problem. Factors such as over-the-counter availability of antibiotics, lack of stringent prescription regulations, and limited awareness among both practitioners and patients contribute to the misuse of these drugs (Laxminarayan *et al*., 2016). Nashik City, a prominent urban area in Maharashtra, exemplifies these challenges. Its rapid urbanization and growing healthcare demands have led to increased antibiotic consumption, further exacerbating the issue of resistance. Studies indicate that the indiscriminate use of antibiotics in both clinical and

community settings has facilitated the emergence of multidrug-resistant bacterial strains in the region (Wagh *et al*., 2021; Kumar *et al*., 2022).

Broad-spectrum antibiotics, often prescribed as first-line treatments, are particularly implicated in the development of resistance. These antibiotics target a wide range of bacteria, including commensal organisms, leading to greater selective pressure for resistance (Jani *et al*., 2018). Despite guidelines advocating the use of narrow-spectrum antibiotics when appropriate, healthcare practitioners frequently prescribe broad-spectrum antibiotics due to diagnostic uncertainty, patient demand, or a lack of rapid diagnostic tools (Llor and Bjerrum, 2014).

Environmental factors further compound the problem of antibiotic resistance in Nashik. The Godavari River, which flows through the city, has been identified as a reservoir of resistant bacteria. Untreated sewage, hospital effluents, and pharmaceutical waste are often discharged into the river, promoting the proliferation of resistant strains (Jani *et al.,* 2018). These resistant bacteria can then spread through water sources, posing risks to public health and contributing to community-acquired infections (Sharma *et al.,* 2021).

To address these concerns, this study examines the antibiotic prescription practices of healthcare practitioners in Nashik City, evaluates the resistance patterns observed in clinical isolates, and explores factors influencing antibiotic misuse. By combining survey data with laboratory analysis, the study aims to provide actionable insights for improving antibiotic stewardship in the region. Additionally, it seeks to assess the impact of educational interventions on practitioners' prescribing behaviors and their awareness of antimicrobial resistance.

The findings of this study will contribute to the growing body of evidence on the urgent need for comprehensive strategies to mitigate antibiotic resistance. These strategies must include strengthening diagnostic infrastructure, enforcing stricter regulations on antibiotic sales, enhancing medical education, and addressing environmental contamination with resistant bacteria (O'Neill, 2016; Wagh *et al.,* 2021).

Materials and Methods

The study employed a mixed-method approach, combining a survey among medical practitioners with data collection from local clinical laboratories. The survey included allopathic and ayurvedic practitioners, medical representatives, pharmacists, and students. Clinical sample analysis focused on bacterial pathogens isolated from various clinical sources, including urine, pus, and blood, and the antimicrobial resistance patterns of these pathogens.

Population and Sample Size

Table 1 provides an overview of the population and sample size used in the study. A total of 275 medical practitioners were approached, of which 228 responded, yielding an 82.9% response rate. Practitioners' ages ranged from 25 to 60 years, with a median age of 46 for males and 42 for females.

Table.1 Population and sample size used in the study

Respondents	Population	Sample Size
Allopathic practitioners	960	150
Ayurvedic practitioners	858	125
Zonal Managers	75	10
Sales representatives	450	50
Pharmacists	200	30
Retailers	650	70
First Year Science Students	750	100

Results and Discussion

Demographic Profile of Medical Practitioners:

The surveyed medical practitioners included both male and female professionals from a variety of medical specialties. Table 1 shows the educational qualifications of the practitioners. A significant number of respondents were B.A.M.S. and M.D. holders, with females dominating the field of pediatrics (M.D. Children).

Antibiotic Prescription Practices

Before and after exposure to educational communication material, the practitioners' antibiotic prescribing habits were assessed (Tables 2 and 3). Before intervention, 79 practitioners prescribed broad-spectrum antibiotics as first-line treatment where narrow-spectrum antibiotics would have sufficed. Post-intervention, this number

increased to 126, indicating a concerning trend towards overprescription of broad-spectrum antibiotics, likely due to diagnostic uncertainty or patient demand.

Factors Influencing Antibiotic Prescription

Tables 3 and 4 outline the key factors influencing antibiotic prescription. Pre-test results indicated that patient satisfaction and cost of treatment were major influences, while concerns about antibiotic resistance ranked lower. However, post-test results showed a slight increase in awareness regarding antibiotic resistance (from 61 to 79 mentions).

Medical Practitioners' Opinions on Preventing Antibiotic Misuse

Both pre- and post-test results highlight a consensus among practitioners on the importance of improving diagnosis, ensuring proper antimicrobial guidelines, and raising awareness about antibiotic use. Post-intervention, there was a marked increase in support for rapid culture and sensitivity tests, from 78% to 93%, and for availability of low-cost antimicrobials (from 80% to 84.6%).

Bacterial Pathogens and Resistance Patterns

Table 5 presents the isolation of bacterial pathogens from clinical samples, with *Staphylococcus* and *Escherichia coli* being the most prevalent. Resistance to common antibiotics was also recorded, with *Staphylococcus* showing a 72% resistance to penicillin and *Escherichia coli* showing a 92% resistance to cephalosporins (Table 5). This highlights the growing concern about multidrug-resistant organisms in the region.

Table.2 Demographic Profile of Medical Practitioners

Educational Status	Male (%)	Female (%)	Total (%)
MBBS	16.5	16.83	16.66
M.D. (Medicine)	18.11	4.95	12.28
M.D. (General Surgery)	18.11	15.84	17.10
M.D. (Children)/DCH	14.17	29.70	21.05
B.A.M.S./M.D. Ayu.	24.12	8.33	32.45

Table.3 Antibiotic Prescription Practices during Pre-Test and Post-Test

Category	Pre-Test	Post-Test
Broad-spectrum antibiotics	79	126
Following standard tests	64	60

Table.4 Factors Influencing Antibiotic Prescription

Category	Pre-Test	Post-Test
Antibiotic resistance concern	61	79
Improper diagnosis	25	41
Patient satisfaction	100	112
Cost of treatment	64	79

Table.5 Antibiotic Misuse pre- and post-test results

Suggestions	Pre-Test (%)	Post-Test (%)
Proper Diagnosis	42.98	55.70
Awareness about antimicrobials	78.50	91.22
Availability of low-cost antimicrobials	80.26	84.64
Rapid culture & sensitivity tests	78.07	93.28

Table.6 Bacterial Pathogens and Resistance Patterns

Microorganism	Number of Isolates	Resistance to Penicillin (%)
Staphylococcus	64	72
Escherichia coli	44	92
Acinetobacter	14	54
Streptococcus	21	43
Pseudomonas	28	37

The findings of this study provide a comprehensive insight into the antibiotic resistance trends in Nashik City, Maharashtra, and align with global concerns regarding the overuse and misuse of antibiotics. The results revealed that the practice of prescribing broad-spectrum antibiotics as first-line treatment, even when narrow-spectrum options would suffice, is prevalent among healthcare practitioners in the region. This practice is concerning as broad-spectrum antibiotics target a wider range of bacteria, leading to greater selective pressure for resistance, which ultimately diminishes the effectiveness of these drugs (WHO, 2020). In this study, 55.26% of medical practitioners were found to prescribe broad-spectrum antibiotics without adequate diagnostic confirmation, even after educational interventions (Table 3,4).

The study also demonstrated that *Staphylococcus aureus* and *Escherichia coli* were the most commonly isolated pathogens from clinical samples, both of which exhibited significant resistance to widely used antibiotics. *Staphylococcus aureus* showed a 72% resistance rate to penicillin, and *Escherichia coli* displayed a 92% resistance rate to cephalosporins (Table 4). These findings are consistent with other studies in India, which have reported high resistance rates to these antibiotics, particularly in urban settings where antibiotic misuse is more rampant (Wagh *et al.,* 2021; *Jani et al.,* 2018). The resistance to cephalosporins and other beta-lactam antibiotics among *Escherichia coli* is particularly alarming, as these are commonly used to treat urinary tract infections (UTIs) and other bacterial infections (Kumar *et al.,* 2022).

A significant factor influencing antibiotic misuse is the pressure to meet patient expectations, which often leads to the unnecessary prescription of antibiotics for viral infections or non-bacterial illnesses. This study found that 100 practitioners cited patient satisfaction as a primary reason for prescribing antibiotics, even in cases where they were not necessary (Table 5). The influence of patient expectations on prescription behavior has been well-documented in previous research, particularly in developing countries where access to healthcare is often constrained by socioeconomic factors (Laxminarayan *et al.,* 2016). Practitioners may feel compelled to provide immediate relief to patients, leading to the overuse of antibiotics, which fuels the spread of resistance.

Another major concern highlighted in this study is the lack of proper diagnostic testing before prescribing antibiotics. Although rapid diagnostic tests can guide more appropriate antibiotic use, their availability in Nashik is limited. Pre-test results indicated that only 64 practitioners followed standard diagnostic tests before prescribing antibiotics (Table 4), and while this number improved slightly after interventions, the gap remains significant. This underscores the importance of improving diagnostic infrastructure in both public and private healthcare sectors. Similar studies have shown that in regions where rapid culture and sensitivity tests are accessible, the prescription of antibiotics is more judicious, leading to lower resistance rates (Jani *et al.,* 2018).

The study also points to the need for enhanced medical education and awareness programs. Post-intervention data showed improvements in the awareness of antimicrobial resistance and the importance of appropriate antibiotic use (Table 5). For instance, the number of practitioners advocating for proper guidelines for prescribing antimicrobials increased from 60.52% pre-intervention to 82.89% post-intervention, indicating that educational campaigns can significantly impact prescribing behavior. This is supported by evidence from other regions of India, where continuing medical education (CME) programs have been shown to improve practitioners' understanding of resistance patterns and appropriate antibiotic use (Wagh *et al.,* 2021).

The resistance patterns observed in the clinical isolates also raise important questions about the role of

environmental factors in the spread of antibiotic resistance. Nashik's proximity to the Godavari River, which has been identified as a reservoir of resistant bacteria due to pollution from untreated sewage, may contribute to the high levels of resistance observed in the study (Jani *et al.,* 2018). The contamination of water sources with antibiotics from pharmaceutical manufacturing and hospital waste further exacerbates the problem, as it promotes the development of resistant strains that can easily spread within the community.

The study also highlights the importance of regulating the over-the-counter sale of antibiotics, which remains a significant issue in India. In the post-test survey, 194 practitioners emphasized the need for stricter regulations on the sale of antibiotics without prescriptions, a substantial increase from the 7 practitioners who mentioned it in the pre-test survey (Table 4, 5). The unrestricted availability of antibiotics in pharmacies is a key driver of resistance, as it allows for self-medication and improper use of these drugs. Similar findings have been reported in other parts of India, where over-the-counter access to antibiotics has been linked to increased resistance rates (Laxminarayan *et al.,* 2016).

In conclusion, the study underscores the urgent need for a multi-faceted approach to tackling antibiotic resistance in Nashik City. This includes improving diagnostic capabilities, enhancing medical education, enforcing stricter regulations on the sale of antibiotics, and addressing environmental contamination with resistant bacteria. Only through coordinated efforts involving healthcare practitioners, policymakers, and public health officials can the growing threat of antibiotic resistance be mitigated.

In conclusion, antibiotic resistance in Nashik City is a critical public health issue, driven by overprescription and improper diagnostic practices. The study demonstrates the importance of targeted interventions, such as educational campaigns and improved access to diagnostic tools, to mitigate the misuse of antibiotics. Regulatory bodies must also enforce stricter controls on the sale and distribution of antibiotics to prevent further resistance development.

Data availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Author contributions

Sunil Saundankar: Investigation, analysis, writing original draft, Ram Bhajan Kumawat: Methodology, investigation, writing, Investigation, analysis,

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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How to cite this article:

Sunil Saundankar and Ram Bhajan Kumawat. 2026. Antimicrobial Resistance Surveillance: An Epidemiological Case Study from Nashik City, Maharashtra, India. *Int.J.Curr.Microbiol.App.Sci.* 15(1): 121-126.
doi: https://doi.org/10.20546/ijcmas.2026.1501.014