DOI: https://doi.org/10.70749/ijbr.v3i7.1775

INDUS JOURNAL OF BIOSCIENCE RESEARCH
https://ijbr.com.pk
ISSN: 2960-2793/ 2960-2807

Antimicrobial Resistance (AMR) Crisis Novel Strategies for Antibiotic Stewardship and Discovery

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ARTICLE INFO

Keywords: Antibiotic Use, Antimicrobial Resistance, Knowledge, Attitudes, Behavior, Awareness Campaigns, Misuse, Public Health, Education, Pakistan.

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Declaration
Authors' Contribution
All authors equally contributed to the study and approved the final manuscript

Conflict of Interest: No conflict of interest.

Funding: No funding received by the authors.

Article History
Received: 01-07-2025 Revised: 14-07-2025
Accepted: 26-07-2025 Published: 02-08-2025

ABSTRACT

The purpose of the study was to examine the knowledge, attitudes, and behaviors of the population against antibiotic use and antimicrobial resistance (AMR) and analyze how such factors as age, education, and awareness campaigns influence antibiotic misuse. Structured questionnaires were used to survey 250 samples consisting of patients and general people in Punjab, Pakistan. Using descriptive statistics, 46 percent of the respondents advised on inappropriate use of antibiotics like taking them without prescription or failing them, among others. Pearson correlation demonstrated that there is a definite positive connection between knowledge and attitudes ($r = .482$, $p < .01$) i.e. more informed people displayed more responsible attitudes regarding AMR. The regression analysis revealed that both age (0.241, $p = .001$) and the educational level (0.289, $p = .001$) were predictors of misuse power but the segment occupation type was not significant (0.132, $p = .080$). The model was significant, 26.3 of the variance was explained in the misuse behavior. Due to the significant difference in the tendency to use antibiotics without proper reasons among people who were exposed to awareness campaigns (chi-square = 12.346, $p<.001$) the results of the chi-square analysis were presented along with the mentioning of the significance value, $p <.001$. The results are consistent with previous research that identifies the power of the education of the population in managing AMR. These outcomes imply that the misuse of antibiotics can be decreased by raising awareness, enhancing access to the right information, and educating every population group, in particular, younger generations. The study recommends beefed-up public health promotion, increased regulatory control of prescriptions, and policy-based preventive measures that would avert the increasing risks of antimicrobial resistance.

INTRODUCTION

Antimicrobial resistance or AMR is emerging as one of the most serious health issues globally. It occurs when living organisms, such as bacteria, viruses, fungi or parasites no longer react to drugs that had formerly been killing them[1]. These germs evolve and end up being more powerful and the drugs that once worked effectively do not affect them in any way. What this implies is that, most of the infections that are common, like sore throat, urinary tract infection or chest infections, would become extremely difficult to tackle. Individuals with these infections do not recover soon[2]. As a matter of fact, they might have to remain in the hospital, use costlier drugs, and stand a better risk of mortality. The problem of AMR is of interest not only to one group of the population, it can also concerns children, adults, and seniors. Among the most critical causes of this issue, it is possible to note that antibiotics are overused and implemented improperly. Antibiotics should be taken when they are not even needed as a person may take them so as to have a cold or influenza, but these conditions can only be caused by viruses[3]. Viruses are not affected by antibiotics yet they are used anyway. In some other incidences, individuals purchase antibiotics without consulting a physician, or they even cancel using the medicines earlier before the germs are eliminated. At the time the antibiotics are not applied properly the strongest germs are left[4]. These powerful germs will then increase, reproduce and infect other individuals.

One of the greatest accomplishments that took place in the medical world in the 20 th century was the discovery of antibiotics. These potent drugs assisted physicians to treat infections that killed millions of people in the past. Due to the antibiotics, human beings began to live longer and healthier lives. Numerous severe conditions such as pneumonia, tuberculosis and post-operative infection were curable. During a rather long period of time, new kinds of antibiotics were discovered by researchers and saved the lives of hundreds of thousands of people[5]. The process (development of new antibiotics) however, has slowed in the past few decades. Today hardly any new antibiotics are produced. A factor such as lack of sufficient research by the pharmaceutical industries in this field may be one of the reasons. It is expensive in terms of money and time to develop a new antibiotic and profit in it is not so great by the companies. Thus they concentrate on other form of medicines that earn them more money[6]. Meanwhile bacteria are growing stronger and smarter. They are evolving into the much stronger shapes, making them impervious to the strongest antibiotics in our domain. What this implies is that our medicines are gradually becoming ineffective. Experts have branded this issue a silent pandemic due to its silent increment as the world concentrates on other issues. Researchers are calling on us to take serious measures to halt this unless we are going to lose more lives to infections by drug resistance germs than we are currently losing to cancer at the third decade of the twenty first century [7].

Simultaneously with the effort to pay more attention to the use of antibiotics, another approach that should be sought is the discovery of new and improved methods of infection treatment. This is highly vital since the old antibiotics are no longer effective[14]. In a bid to counteract the harmful germs, scientists all over the world are trying to identify alternative medication that could be used. The phage therapy forms one of these new concepts where special viruses known as phages are used in killing harmful bacteria[15]. These are pathogenic viruses that could identify and eliminate the bacteria without causing damage to human cells. The other novel method is the application of antimicrobial peptides that are natural proteins in the bodies of animals and human beings. These are the proteins, which assist in combating the infections without chemically interfering with the body [16].Scientists are also employing recent technology such as the use of artificial intelligence (AI) to aid in the faster tracking of the new medicines. AI is able to search through huge quantities of data and enable scientists discover potential new drugs faster than usual methods. Gene editing is also an enthralling research avenue on which scientists attempt to modify the genes of germs to prevent disease. They are also going to look back to the natural sources, such as plants, soil, and marine life, to identify new substances that may be used as antibiotics [17].However, one country cannot do this independently, and thus there should be collaboration between different nations in the process of finding new treatments.

Antimicrobial resistance (AMR) is developing to be a major international health issue. It arises because when diseased germs such as bacteria, viruses fungi or parasites no longer respond to the medicines that previously killed them. Consequently, infections are increasingly difficult to cure and they are also slow to heal[18]. Without the decisive measures taken by the governments, even minor infections and minor traumas could kill once again, as it happened when the World Health Organization (WHO) declared the emergence of an extraordinarily transmitted disease [1]. AMR is no longer restricted to hospitals, but it is invading society and farms on a global level [19].This indicates that AMR is not a local issue and it is a global-wide challenge. Researchers have identified some of the factors related to AMR including excessive use of antibiotics, negatively utilizing them without prescription, and failure to take a full course[20]. The situation is also compounded by the use of antibiotics in farming that is aimed at enhancing the growth of animals. The other cause is lack of infection prevention within clinics and hospitals. The germs spreads easily in the case where there is poor hygiene. What adds to the problem is the fact that finding new antibiotics is a long process[21]. The fact is that the research of antibiotics is not very profitable and expensive, so pharmaceutical companies do not make great financial inputs in the given field. Experts are convinced that unless the way of using antibiotics changes and new medicines begin to be sought, AMR will continue to increase.

In the past, research had clearly demonstrated that overuse and misuse of antibiotics in humans and animals is one of the dominant factors that have contributed to the growth of antimicrobial resistance (AMR). Antibiotics are also not taken when they are actually required or they are taken in an improper manner. In a famous investigation by[22], it was observed that the share of the antibiotics utilized in food production animals was more than 60 percent higher in 2010 contrasted with the situation in 2000, without showing any indication of leveling off [23].It is a grave issue since in the event of the regular administration of antibiotics to animals, they may develop resistant bacteria in their bodies. They are then capable of spreading these resistant bacteria to human beings via food, water or environment. In hospitals, things are also alarming. As a study by [24].discovered, the doctors frequently supply the patients with antibiotics without ensuring the nature of an infection and the necessity of the medicine in question [25]Such an irresponsible utilization assists bacteria to evolve and become more robust and resistant to killing. Due to this reason, the health experts currently advocate very highly on the need to enhance antibiotic stewardship. This implies that there should only be the right prescription of antibiotics when they are really needed. Most scientists are of the opinion that this can be achieved through training of doctors, pharmacists and clear directions on treating patients and sensitizing the population on the dangers of antibiotic misuse [26].Such measures will have the potential of minimizing resistance and the power of antibiotics in the future.

Another critical issue that has been outlined in the existing studies is a sluggish rate of the creation of new antibiotics. As the bacteria are continuously becoming resistant, no important kind of antibiotics was detected since the 1980s. It is such an alarming problem that it was also discussed in one of the most popular articles by [27],who points out that we are now running out of drugs that could help us fight against dangerous infections

[28].This to great extent has been brought about by the fact that the majority of pharmaceutical firms are not keen on funding antibiotics research. The reason is that; it will take a lot of money and years to make new antibiotics and some antibiotics may generate small returns since antibiotics are only used within a short time and people only use them when in emergency. The implication of this is that companies will become more attracted to medicines that will be marketed, say, in the long term such as medicines to help in the treatment of diabetes or a heart attack. New forms of treatment is a solution that researchers are finding as a cure to this. Some of the tools that some are using to speed up the process of compound discovery are artificial intelligence (AI) and machine learning [29].People who turn to natural resources are studying plants, fungi or even sea creatures, which have a potential of containing powerful antibacterial compounds. Such alternatives as phage therapy (an alternative to killing the bacteria with viruses) and gene editing are being tested as well as promising. These ideas have recorded positive results in the preliminary studies and are yet to be in the testing processes [30].This illustrates that it implies that despite the innovations created, it still involves more efforts, financial expenditures, and cooperation with different countries in order to bring them to life in treating people.

Research Objectives

1. To examine the relationship between public knowledge of antibiotic use and attitudes toward antimicrobial resistance.
2. To predict the likelihood of inappropriate antibiotic use based on demographic factors such as age, education, and occupation.
3. To assess the association between antibiotic misuse behavior and awareness campaigns across different population groups.

The problem of antimicrobial resistance (AMR) is increasingly becoming a significant health problem in the world, as it becomes increasingly difficult to treat common infections. This is the case when antibiotics become inefficient due to the frequent or improper use. Most of these individuals disuse antibiotics by either ceasing to take them before the completion of the full regime or over-taking them by taking antibiotics without the recommendation of doctors. That gives the harmful bacteria room to live and become much stronger. Meanwhile, occurrence of new antibiotics is minimal at the same time, a situation that worsens the situation. AMR results in an increased chance of severe conditions, protracted hospitalization, and even death. These issues have been noted in the previous studies although there is still a gap to know how knowledge, behavior and awareness activities of people are related with the abuse of antibiotics. The given research tries to investigate these aspects and observe their connection with one another. It will examine these links using statistical instruments. The results can benefit health care workers, policy makers, as well as educators in developing improved strategies to curb antibiotic abuse. It can also direct awareness programs in order to educate people on the use of antibiotics. The research will help to understand the most important factors contributing to misuse and assist in the attempt to decelerate the development of AMR. This may be useful in the long run to safeguard the health of the people and also enhance the efficacy of therapies.

MATERIALS AND METHODS

A quantitative and cross-sectional research design was used in this study; meaning that representative sample of the population was chosen at a specific time to investigate the relationship that exists between knowledge, behaviours and awareness level of the respondents towards antibiotics and antimicrobial resistance (AMR). This approach was taken because it allowed the researcher to quantify and analyze the current level of the population cognizance and practices without requiring a follow up in any way. The conducted cross-sectional study held in February to June 2025 provided a handy image of the attitude of the population, which allowed determining not only the existing trends but also the possible absence of awareness. The way it was measured by using the structured data collection made data quite uniform as all the participants were asked the questions in the same pattern and helped in coming up with a uniform result which was reliable as well as comparable between different groups. It assisted in generating information that could be generously used statistically because it gives the idea about how the general population interacts with the AMR-related subjects in the specified time differences.

The target population in this study was members of the general population (urban and semi-urban areas in Pakistan) in Punjab. The respondents were selected to be of age 18-60 and drawn down the scale of education, occupation, and financial status. This broad representation was critical to ensure the study got a broad range of views right up to the views of persons who may have more information regarding issues of healthcare and other persons who may have less information regarding healthcare issues. The researcher connected with individuals in places of popular gathering such as hospitals, universities, markets, and parks, which assisted the researcher to capture the perspectives of diverse individuals in the areas of common life but did not reflect only people of certain social or professional circle. Such a method provided the research with a more comprehensive, more reality-based perception of the way various groups of individuals within the society are likely to observe and deal with the antibiotics and AMR.

The number of people in the final sample used in the study was 250. This number was deemed appropriate in conducting statistical tests like correlation, regression, and chi-square of analysis which needs a number of responses in order to come out with meaningful and valid results. The selected sample was large enough to ensure the high ratio of statistical power and small enough to maximize the possibilities of time and resources of the researcher. Using this number, the study has succeeded to analyze various subgroups within the population, differences, and associations between the subgroups may include people with higher or lower education levels, occupations or persons facing different exposure to the healthcare Setting. It allowed identifying certain areas in which people might be poorly informed or acting (or behaving) and, therefore, focus on developing the knowledge (or behavior) of the population; or, alternatively, it allowed setting trends that the public health teaching efforts or policy makers might want to engage in to eliminate the use of antibiotics improperly and mitigate the problem of resistance.

The sample of participants in this study entailed the use of convenience sampling, a non-probability sample where the criterion of selection is based on its ease of accessibility to the user and his or her desire to help. Although the given technique is not likely to produce a fully representative sample of the broader population, it was a viable and effective option to the study in terms of time and resource restrictions. The ease of access of people in the public areas made the researcher sample the people easily and this facilitated the speed at which a broad and diverse sample of the responses was gathered. This approach was also facilitated in collecting the opinions of the individuals in the natural environment that provides a real picture of the perception and application of antibiotics in the real life. Nonetheless, inconvenience sampling was useful given the nature of the exploratory study, in that the study was able to get first-hand knowledge of the way the people perceive and use antibiotics and AMR in real-life establishments.

RESULTS

Table 1

Pearson Correlation Analysis

Variables	1. Knowledge Score	2. Attitude Score
1. Knowledge Score	1	.482**
2. Attitude Toward AMR	.482**	1

It was found that there is a positive statistically significant correlation between knowledge regarding the usage of antibiotics and attitude towards antimicrobial resistance ($r = .482, p < .01$). It shows that those who attain better knowledge scores are more responsible and informed towards AMR. The value of the correlation indicates that the correlation is moderate, which indicates that the more knowledgeably people get with regard to antibiotics, the more they are aware and concerned with antimicrobial resistance. These results indicate the necessity to conduct education among the population to enhance the attitudes and behaviors regarding antibiotics use and resistance antibiotic use and resistance.

Table 2

Multiple Regression Analysis

Predictor Variable	B	SE B	Beta	t	Sig.
(Constant)	4.212	0.498	—	8.458	.000
Age	-0.036	0.011	-0.241	-3.273	.001
Education Level	-0.274	0.079	-0.289	-3.468	.001
Occupation Type	0.109	0.062	0.132	1.758	.080

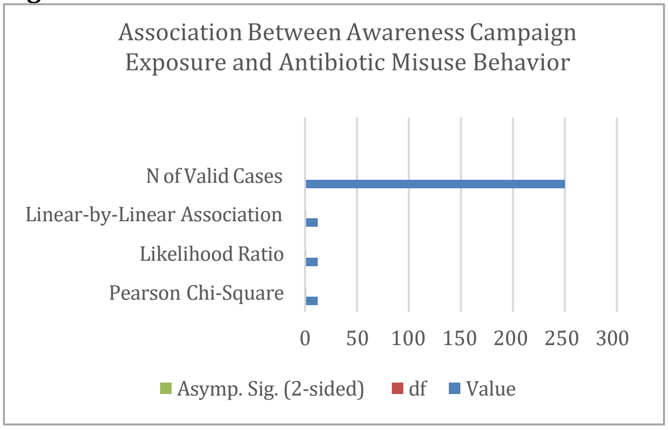
The multiple regression analysis showed that the age and education level were likely to predict inappropriate antibiotic use, but the occupation type was not found to be significant. More precisely, the impact of age was negative (beta = -0.241, p = .001), meaning that the greater age is the fewer chances there are to use the unsuitable antibiotics. Likewise, the education level also displayed a major negative correlation (b= -0.289, p= .001) implying that misuse of antibiotics is less among highly educated people. The type of occupation although it had a positive coefficient (beta = 0.132) was non-significant (p = .080) indicating the type of job may not play a vital role in the use of antibiotics in this sample. The rest of the model was substantial, $F(3, 246) = 30.957$, $p < .001$ and explained about 27.5 percent of the variance in inappropriate use of antibiotics (Adjusted R^2 =.263)..

Table 3

Chi-Square Analysis

Test Statistic	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	12.346	1	.000
Likelihood Ratio	12.482	1	.000
Linear-by-Linear Association	12.201	1	.000
N of Valid Cases	250		

Figure 1



According to the Chi-Square analysis, there has been a significant relationship between exposure to awareness campaigns and the antibiotic misuse behavior (Pearson 2 (Chi 2) = 12.346,2 degrees of Freedom = 1, p < .001). This means that the individuals that were previously exposed to awareness programs had a significantly low chance of misusing the antibiotics than those that were not exposed. The high level of significance (p < .001) indicates that awareness campaigns are an effective determinant of antibiotics responsible use, which is why the issue of public health education should remain one of the central pieces of the puzzle in the battle against antibiotic resistance.

DISCUSSION

The results of this research are valuable in terms of the role that knowledge, attitudes and exposure to the awareness campaigns play in changing the behavior of people connected to antibiotics and antimicrobial resistance (AMR). A positive correlation between the levels of knowledge and attitudes toward AMR was obtained through Pearson correlation analysis: r =.482, p, <.01, indicating a moderate and statistically significant connection between the attitudes toward AMR and the levels of knowledge. It implies that those individuals who were better informed about the conditions and ways in which antibiotics might be used were also likely to possess responsible attitude and realize the risks of inappropriate application of such medications. The finding backs up the previous research on the topic, like the one conducted by [31]and showing that people pay a lot of attention to what they know about antibiotics in choosing the option of their use. On the same note, there was one that was done in Europe by [32],and it revealed that people who had more knowledge on antibiotics had less chances of requesting them in case of viral infections. This connection between knowledge and attitude is very crucial since it demonstrates that the increase in awareness and education of people might have a beneficial impact on conduct and cause a reduction in the pace of spread of resistant germs.

The multiple regression analysis further validated that the demographic issues namely age and education are of foremost importance in the prediction of antibiotic abuse. Age revealed a significant but negative impact in this study [33], this indicates that young individuals have higher chances of abusing antibiotics than older ones. The education level was also correlated negatively though significantly with the misuse (beta = -0.289, p = .001) implying that with increased level of education people were less likely to engage in improper use of antibiotics. This concurs with the previous studies conducted by[34], where individuals with a worse education level had a greater number of antibiotics misconceptions and tended to abuse antibiotics. Likewise, a research study carried out in India by [30].revealed too that education is indeed one of the main determinants of minimising antibiotic self-medation. Remarkably, the occupation type had a weak positive indication as well (P = 0.132), but not enough to be mentioned as statistically significant (P = 0.080). This indicates that the nature of job might be a less significant variable in prescribing the occurrence of the misuse as the age and the education-level. The overall model was statistically significant (F (3, 246) = 30.957, p < .001) and had an Adjusted R 2 26.3 which means that age and education are significant but will not provide the correct interpretation of the behavior as there may be other factors, eg. cultural beliefs, access to healthcare, and health literacy level does contribute.

Altogether, this research proves that the issue of antibiotic abuse remains a common issue and that it is strictly associated with the knowledge, the age, and the education level of people along with their exposure to the information campaigns. Although the research results can be compared at a global level with previous research results, they may also indicate issues peculiar to the local setting of the work, Punjab region, Pakistan such as drugs availability over the counter to any person without a prescription and the non-enforcement of the drug regulation policies. The paper favors the notion that such enhancements of knowledge by specific awareness creation and encouragement of health education at community levels can play an actual role of influencing behavior in a meaningful way. Otherwise, the abuse of antibiotics will inevitably increase, and antimicrobial resistance will become a threat to the lives of millions of people, complicating its treatment of infections. The World Health Organization noted that AMR is not a risk in the future; it is an ongoing crisis, which needs to be addressed ASAP on both the public and policymaker levels.

CONCLUSION

In conclusion, the current study proves the fact that the issue of antimicrobial resistance (AMR) is critical and close to the patterns of antibiotic use, awareness, and attitudes of individuals. A share (25.6%) of all people who participated in this research misused antibiotics i.e. use of antibiotics, even without a medical prescription or without finishing the entire course. The age and education was held to be a major contributing factor- the older and the less educated were less probable to abuse the antibiotics. Besides, those affected had watched awareness programs and thus could not abuse them as seen through the Chi-square value which was significant (2 = 12.346, p < .001). It was still true that there was strong relationship between enhanced knowledge and elevated responsibility attitudes (r =.482, p <.01). These findings are a sign indicating that the educational process ought to empower us to control the improper use and fight AMR. Even educated people should also be instructed through better information and stupid individuals. It will be possible to address this issue through health education, stricter prescriptions regulations as well as additional informational campaigns. It will be in a position to preserve the antibiotics by making sure that they are effective in future.

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