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## Socioeconomic Determinants of Antibiotic Resistance

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Socioeconomic Determinants of Antibiotic Resistance

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## **Abstract**

### **Background**

Antibiotics were first developed to treat wounded soldiers and cases of pneumonia in World War II. By the 1940s, antibiotics became widely used to treat several infectious processes. It was not long after antibiotics were being used frequently by clinicians that resistant strains began to emerge. Today, antibiotic resistance is a growing global health concern seen in many parts of the world. There are many factors that contribute to the prevalence of antibiotic resistance.

### **Purpose**

This paper aims to demonstrate how socioeconomic factors play a role in the development and spread of antibiotic resistance. The literature review focused on economics, education, culture, and environment as potential causes for the acceleration of antibiotic resistance seen globally.

### **Methods**

Databases such as PubMed, Google Scholar, and ScienceDirect were used to find articles that help provide evidence on this topic. Cross-sectional Studies, surveys, and longitudinal studies were included in the paper.

### **Conclusion**

After analyzing the studies, results showed that poor economics, lack of access to health, poor health literacy, and poor infrastructure all contribute to the rise of resistant pathogens. In conclusion, to improve antibiotic resistance, public health initiatives need to take place to improve education and awareness surrounding socioeconomic determinants of resistance.

**Keywords:** antibiotic resistance, socioeconomic factors on antibiotic resistance, environmental impacts on resistance, lack of healthcare, self-medication, poor infrastructure.

## Introduction

Antibiotic resistance is defined as microbiomes that resist the effects of the bacteriostatic and bactericidal mechanisms of antibiotics and continue to grow through various mechanisms. Antibiotic resistance does not mean that humans become resistant to the antibiotic treatment, but rather that the bacteria become resistant to the antibiotic. When this occurs, bacteria can proliferate and even form biofilms which can be difficult to eradicate with just one antibiotic class. This creates a major problem for individuals because it can cause infections to persist or new ones to form. Antibiotic resistance has been a huge threat to global health, food security, and development in many areas of the world. According to the CDC, more than 2.8 million resistant infections occur just in the U.S. each year.<sup>1</sup> 70% of the bacteria that cause these infections are resistant to at least one of the antibiotics used to treat them.<sup>2</sup>

There are two main ways in which bacteria can become resistant to antibiotics. One is a genetic mutation that occurs in the DNA of the cell during replication.<sup>3</sup> The other way is through acquired resistance that can be developed as a result of horizontal gene transfer.<sup>3</sup> Once antibiotic resistance develops in an area, it is very easily transmitted. Antibiotic resistance can be transmitted through direct contact with an infected person, food, water, agriculture, animals, and contaminated surfaces.

Although antibiotic resistance is a natural occurrence, many factors can accelerate the process, including overprescribing and misuse of medications, transmission of infectious agents, growth of new bacteria, and the lack of new antibiotic development. Although the evolution of science and progression of modern medicine over time can account for many of these factors, evidence also suggests that social determinants such as poverty, education, and environment can play a role in antibiotic resistance as well. Understanding and exploring these social factors can

help identify areas of focus for public health initiatives that aim to reduce antibiotic resistance globally. Addressing these social determinants of health can also lead to another long-term benefit which is increasing the practice of preventive medicine.

This paper focuses on social determinants of antibiotic resistance including economics, education, culture, and environment that contribute to the emergence of antibiotic resistance. While many different social determinants influence this phenomenon, this paper specifically focuses on these main aspects to highlight the importance of understanding social determinants as a potential factor for resistance. To answer the research question: can socioeconomic factors play a role in antibiotic resistance, this literature review will first provide some historical background related to antibiotic resistance including the discovery of antibiotics, rise of resistant infections, mechanisms of resistance, biofilm formation, antibiotic stewardship, and an insight into social determinants of health.

Then, the paper will analyze research studies that aim to provide further evidence that will help support the argument and answer the PICO question stated above. The articles are divided into sections in a way that helps the reader understand how each social factor builds on the other and formulates a comprehensive discussion.

Lastly, the articles are tied together with a discussion analysis that further breaks down the studies and a conclusion that reiterates the purpose of the study and provides the answer to the research question.

## **Methods**

The PubMed, Google Scholar, and ScienceDirect databases were used to find research articles related to socioeconomic factors that play a role in antibiotic resistance in different parts

of the world to complete a comprehensive literature review. Search terms included: history of antibiotic resistance, socioeconomic factors that influence antibiotic resistance, misuse of antibiotics, overprescribing antibiotics, self-medication with antibiotics, and environmental impacts on antibiotic resistance. Inclusion criteria consisted of original articles and prospective studies. Exclusion criteria consisted of systematic reviews and meta-analyses.

## **Background**

Alexander Fleming discovered the first class of antibiotics, Penicillin, in 1928.<sup>4</sup> However, it wasn't until World War II that antibiotics made a dramatic impact on civilians.<sup>4</sup> They were used on the battlefield to treat wound infections and pneumonia. By the late 1940s, it became more widely used by the general public.<sup>5</sup> It was a turning point for antibiotic use in clinical practice. Soon enough, providers were prescribing antibiotics more than any other drug. Fleming predicted “the era of abuse”, as antibiotics were becoming largely overused.<sup>4</sup> It was not long after the use of Penicillin that scientists discovered resistance was going to play a role in the failure of the drug in treating infections. Strains of bacteria namely, *Staphylococcus Aureus* were growing despite the use of Penicillin. Then, Methicillin was introduced in 1959 to combat the resistant bacteria.<sup>4</sup> However, Methicillin soon became ineffective as well with the growth of Methicillin-Resistant *Staphylococcus Aureus*, also known as MRSA, in 1960.<sup>4</sup> In the case of Streptomycin which was introduced in 1944 to treat Tuberculosis, mutant strains known as *Mycobacterium Tuberculosis* was found in the course of treatment.<sup>4</sup>

As antibiotic resistance started to emerge, so did multi-drug resistant infections. Diseases like Tuberculosis, Staph infections, *Clostridium Difficile*, and Cholera started to colonize different areas of the world such as Asia, Africa, and Europe.<sup>4</sup> These infections created

worldwide outbreaks and appeared to be more worrisome in areas of poverty, famine, violence, and natural disasters. With the high rates of morbidity and mortality due to the prevalence of antibiotic-resistant infections, scientists and clinicians contemplated the need for new antibiotics.

As more antibiotics were introduced into clinical practice, more and more resistant strains emerged. Scientists began shifting their research to understanding the mechanisms of antibacterial resistance, heretical gene transfer of bacteria, and biochemical properties of antibiotics. This could lead to the development of new strategies that could potentially avoid resistance. The concept of intrinsic resistance was first introduced in the Fredrick Griffith experiments in 1928.<sup>6</sup> This series of experiments demonstrated how genetic elements could be transferred from dead bacterial cells.<sup>6</sup> Therefore, resistance could be acquired through contact with dead bacteria and be transmitted through different species. Due to the dominance of the resistant gene, it became the gene that was selected in the spread of acquired resistance. This led scientists to believe that the main factor of resistance was overprescribing and overuse of antibiotics.

Another important concept in antibiotic resistance research is biofilm formation and its role in adaptive resistance. Biofilm is a community of bacteria that stick together and are enclosed in a self-produced extracellular matrix made of extracellular polysaccharides that adhere to a surface.<sup>6</sup> These biofilms have posed a threat to antibiotic treatment because they are extremely resistant and most drugs cannot penetrate the surface. Due to these characteristics, biofilms are thought to be the cause of most chronic infections. Researchers began studying a new strategy, antibiofilm agents. Although research regarding antibiofilm agents is still underway, scientists are determined to continue finding new ways to incorporate this new phenomenon into antibiotic resistance research.



With the development of research outlining the mechanisms and patterns of antibiotic resistance, many clinicians, healthcare systems, and policymakers were beginning to find new ways to reduce resistance and have better control over the overuse of antibiotics. Antibiotic Stewardship programs were established to improve the use of antibiotics use by both medical providers and patients thus, improving antibiotic resistance. Healthcare facilities started to see significant progress in the way antibiotics were being utilized. Countries began to notice an improvement in antibiotic resistance. However, the fight against antibiotic resistance was far from over.

Although changes were taking place to combat antibiotic resistance, there were still gaps in research on all the possible ways resistance could be emerging. The social determinants of antibiotic resistance were not considered. Until more recently, established research focused on how genetics and natural selection were the main factors in the increase in resistant patterns. Now, due to evolving literature, we can appreciate how understanding social determinants of health can increase our knowledge and awareness of antibiotic resistance.

### **Literature Review: Economics**

Antibiotic resistance is a multifaceted issue in both developed and developing countries, but one of the common driving forces is poverty and lack of access to higher-quality medications. According to the World Bank, there are 34 million families who live in poverty in the United States and 689 million people globally.<sup>7</sup> Under these circumstances, it is difficult for many individuals to afford healthcare and gain access to higher-quality medications to help treat common infections.

In many developing countries, individuals were prescribed antibiotics to treat non-bacterial conditions due to cost-saving measures. A cross-sectional study was conducted in Yirgalem town, Ethiopia using 568 participants who were all using antibiotics for a whole year before the study.<sup>8</sup> After a series of questionnaires and data collection, the study demonstrated that the magnitude of inappropriate use of antibiotics was 37.9%.<sup>8</sup> The study also found that cost-cutting was among the reasons that the rate of inappropriate use of antibiotics was so high with health facility delays being another factor.<sup>8</sup>

As the costs of medications soar, fewer and fewer individuals are able to afford healthcare and prescription coverage. This leads to many practices that can further the prevalence of resistance such as medication sharing, saving antibiotics to treat other illnesses, and purchasing cheaper antibiotics from other countries to save money. In addition, many of these individuals complete a shorter course of antibiotic therapy due to the inability to pay for the full course. All of these practices are inappropriate ways to use antibiotics and can exert selective pressure on a bacterial species which furthers resistance patterns. Macias et al conducted a study in South Los Angeles County where 14% of the adults were found to have crossed the border into Mexico to address their healthcare needs.<sup>9</sup> 28% of these adults crossed the border to purchase medications with antibiotics and pain medications being listed in the highest frequency.<sup>9</sup>

Lack of access to adequate and affordable healthcare is a growing problem and a major contributor to issues such as antibiotic resistance. As of 2020, 8.6% of people still did not have access to healthcare at any given point of the year.<sup>10</sup> This includes barriers to doctor visits, dental visits, access to diagnostic tests, immunizations, and medications.<sup>10</sup> Without access to these services, many cannot engage in preventive measures that decrease the chance of developing

infections in the first place. Another barrier is the cost of medications. Medications including antibiotics are very expensive and continue to get expensive as new ones are developed. As of 2021, the average cost of a generic antibiotic prescription is \$42.67 and the average cost of a brand-name antibiotic is \$221.75.<sup>11</sup> Along with the base price, the duration of treatment, and quality of the antibiotic can also lead to an increase in prices. This can lead to a financial burden for many families and force many individuals to self-medicate.

Self-medicating is a common practice of individuals who cannot afford medications, or have limited access to healthcare. Unfortunately, this practice provides more harm than benefit for such individuals. One of these harms is antibiotic resistance. Self-medication can lead to resistance due to several reasons including but not limited to inappropriate use of antibiotics to treat viruses, using the wrong antibiotic to eradicate a specific organism and inappropriate duration of therapy. A cross-sectional, questionnaire-based study conducted at five public universities in Bangladesh found that 88% of their 250 pharmacy students, who were selected at random, were self-medicating for many reasons including cost benefits.<sup>12</sup> Another study conducted in India found that 39.1% of the 1021 adults that were interviewed were self-medicating with antibiotics without a prescription.<sup>13</sup> These studies concluded that the inappropriate use of antibiotics was leading to adverse effects and antibiotic resistance.

Although low income, lack of access to affordable healthcare, poverty, and cost-saving opportunities are major contributors to antibiotic resistance, another major aspect of the increase of antibiotic resistance is the lack of hospital funding. Hospital funding is needed to develop new antibiotics or find ways to enhance the use of the existing ones. The lack of technical innovations and hospital funding in many low-income countries leads to the use of low-quality antibiotics and a shift to more expensive second and third-line treatments which are becoming less effective.

The lack of hospital funding also affects the development of diagnostic tests that are needed to narrow down the causative agents of infectious diseases which limit the use of broad-spectrum antibiotics and thus reduce the risk of resistance.

The emergence of resistant infections also creates a financial burden for many of these hospitals and most of them do not have the means to combat resistance. One study conducted in 2019 compared the hospital burden between 1381 patients with non-multi-drug resistant *Pseudomonas Aeruginosa* (*P. Aeruginosa*) and 523 patients with multi-drug resistant *P. Aeruginosa* and found that the patients with multi-drug resistant *P. Aeruginosa* had higher mortality, re-admissions, longer hospital stays, \$20,000 excess hospital costs per case, and more than \$10,000 net loss per case.<sup>14</sup> This example of financial strain not only has negative effects on hospital facilities but also causes negative health outcomes for the patients.

Poverty and economic status do not stand alone in the emergence of antibiotic resistance. Research shows that low-income status and poverty can lead to a lack of access to education and resources needed in communities to understand antibiotic prescribing and resistance patterns. Next, the literature review will show how education can affect antibiotic resistance.

## **Education and Culture**

Education is one of the main aspects of the development, use, and monitoring of antibiotics. It also continues to play a huge role in both the emergence of antibiotic resistance as well as the fight to reduce resistance in many parts of the world. Antibiotic education is not only crucial to the physicians who prescribe it, but it also affects the general public, pharmaceutical companies, policymakers, and the government. In 2019, one in seven Americans (14%) reported that they have heard of the term "antibiotic resistance" but are still unsure of what it means.<sup>15</sup>

Another 15% shared that they have never heard of “antibiotic resistance”.<sup>15</sup> Furthermore, 75% of the respondents who participated in a survey conducted by the World Health Organization think, incorrectly, that colds and flu can be treated with antibiotics, and only 58% understand that they should stop taking antibiotics when the course of treatment is complete.<sup>16</sup> Although education was a strong driving force for global health initiatives that were established to fight antibiotic resistance, it is also the lack of education and misinformation that makes antibiotic resistance a global issue even to this day.

Over time research has shown that one of the key causes of antibiotic resistance is the misuse of antibiotics. Misuse by definition includes but is not limited to using antibiotics for an incorrect period, not using the appropriate antibiotic for a condition, sharing antibiotics, saving antibiotics, using an incorrect dose, and taking more/less than instructed. Many studies demonstrated that poor health literacy plays a huge role in the misuse of antibiotics. For example, a study conducted in Kalamoon, Syrian Arab Republic reported that 19% of the participants took the antibiotics as prescribed, 50% waited until they felt better to stop taking their antibiotics, and only 34% were aware of the potential harms that misusing antibiotics could cause.<sup>17</sup> A different study conducted in a 174-bed community hospital in Saudi Arabia indicated that rates of nosocomial infections and antibiotic resistance were both high.<sup>18</sup> Of the 2441 patients that were included in the study, 79% were found to have multi-drug resistant infections.<sup>18</sup> Over 80% were given either prophylactic or therapeutic antibiotics, and 53% were receiving multiple antibiotics.<sup>18</sup> Of that, 72% of the antibiotics were established to be misused.<sup>18</sup>

Many studies found that there was a strong correlation between the prevalence of antibiotic resistance and the lack of efforts surrounding antibiotic education. Unfortunately, many of these studies take place in low-income communities where education as a whole is not

easily accessible. Without access to the correct information and resources, many do not understand how to correctly use antibiotics and the risks of misusing them.

Another factor that can precipitate the misuse of antibiotics is cultural beliefs and practices. The idea of treating all infections aggressively with antibiotics is not a new practice by any means. This idea has been the central dogma of western medicine since the twentieth century.<sup>19</sup> In the early 1900s, German scientist and physician Paul Ehrlich believed that the best way to treat infection was to eradicate the infectious organism through a long and hard course of antibiotic treatment.<sup>19</sup> Since then, many clinical trials have taken place over many years to contest this belief, however, many practices and cultural beliefs of medicine still rely on Ehrlich's early understanding of infection.<sup>19</sup> Despite the efforts to reconstruct how antibiotics were used, many cultures over time adopted the idea that using antibiotics frequently was the only solution to feeling sick.

In 2012-2013 Porto Novellia, a public relations firm, administered surveys to adults and health care providers living in the United States to assess health-related knowledge and attitudes.<sup>20</sup> The data found that the responses between non-Hispanic and Hispanic adult consumers were dramatically different. The study reported that the Hispanic respondents were more likely to request antibiotics when they were diagnosed with the flu or a cold, to prevent a more serious infection from concurring and to help them feel better quickly.<sup>20</sup> The study also found that the Hispanic respondents were less aware of the potential dangers of misusing antibiotics such as antibiotic resistance and the possible eradication of their 'good bacteria'.<sup>20</sup>

On the other hand, the lack of extensive education on antibiotic use seen amongst physicians, medical students, and healthcare facilities has led to over-prescription which is another form of misuse. Over time, the over-prescription of antibiotics has proved to be the

largest cause of antibiotic resistance. Overprescribing antibiotics means prescribing antibiotics when they're not needed, this can lead to bacteria becoming unresponsive and the formation of multi-drug resistant bacteria. According to the CDC, 30% of the 154 million antibiotic prescriptions in the United States are unnecessary.<sup>21</sup> About 44% of prescriptions are written to treat acute upper respiratory infections, sinus infections, viral URIs, asthma, allergies, influenza, bronchitis, etc.<sup>21</sup> These numbers are heavily influenced by lack of awareness surrounding the guidelines for antibiotic use. A research study was conducted in India to compare the awareness of antibiotic prescribing and resistance amongst MDS and BDS dental practitioners and students.<sup>22</sup> 361 dental professionals were given a questionnaire about antibiotic prescribing.<sup>22</sup> The results showed that over-prescription was significantly more among the BDS practitioners than the MDS practitioners.<sup>22</sup> This data was directly correlated to the lack of knowledge on antibiotic prescribing among the BDS professionals.<sup>22</sup> The survey indicated that 15% of the BDS dental professionals knew the rules of prescribing antibiotics when compared to 71% of the MDS professionals.<sup>22</sup>

This study, like many others, emphasized the importance of antibiotic education in the efforts to minimize antibiotic resistance. Education not only allows prescribers, policymakers, and the general public to be more cautious of their antibiotic use, it is a building block for creating clean and safe environments where infection control is prioritized. Next, environmental factors of antibiotic resistance will be evaluated.

### **Environment and Infection Control**

The growth of urban living is creating new ways for infectious diseases to grow and flourish. More people live in urban cities than in rural areas. In 2020, 56.2% of the world

population was urban.<sup>23</sup> Cities can create opportunities such as jobs and better healthcare, but they can also attract many harmful infectious diseases. Increased crowding, poor air quality, and weak infrastructure can all increase disease risk, particularly for those who live in slums or the inner cities. As more people start to move into the cities, they bring diseases with them which increases the risk of transmission. A study conducted to understand the impact of informal urban settlements on the transmission of cholera in Dar es Salaam, Tanzania found that the Cholera incidence was closely associated with informal housing, population density, and income status of the residents.<sup>24</sup> Data suggested that there's nearly a one percent increase in Cholera incidence for every point percentage increase in informal residents and a two percent increase in Cholera cases for every increase in population density per 1000 per km.<sup>24</sup> An increase in population density and limited hospitals especially in low-income communities leads to crowded facilities and more opportunities for drug-resistant bacteria to spread.

Crowded and multi-generational housing can also increase the chance for resistant bacteria to spread. In many low-income communities, individuals cannot afford to pay for separate housing so they cohabit to manage their living expenses. Often, individuals live in inner-city apartments with as many as 10 residents in a limited space. Unfortunately, living in such close proximity to one another allows for resistant bacteria to spread more quickly. On the other hand, multigenerational housing is also another common practice seen in many cultures. A study tracking cases of Shigella in Manitoba, Canada over a 2-year epidemic cycle from September 1992 to August 1994, compared the rates of Shigella cases detected on Indian reservations to the cases found in the rest of the city population.<sup>25</sup> During the 2 years of the Shigella epidemic, 513 cases were reported in the city of Manitoba.<sup>25</sup> The incidence rate of Shigella cases on the Indian reservations was 29 times greater than the rest of the population.<sup>25</sup>



There were 353 cases of Shigella reported on the Indian reservations and 109 cases reported in the rest of the city.<sup>25</sup> After further investigation, researchers found that household crowding, lack of piped water, and inadequate sewage disposal accounted for the differences in the number of cases between the two communities.<sup>25</sup> Although the study lacked ecological design which can better prove the cause and effect between environmental infrastructure and the risk of disease transmission, the study shows significant results that can illustrate a strong correlation between poor environment structure and the spread of resistant bacteria.

Another possible environmental factor for the spread of antimicrobial resistance is poor or non-existent infrastructure. Poor sanitation and crowded neighborhoods are ideal settings for drug-resistant bacteria to grow. Wastewater that is not properly sanitized serves as a major vector for resistant pathogens.<sup>26</sup> Another possible mechanism for the transmission of resistant bacteria is the release of fecal matter into sewage water via open defecation.<sup>26</sup> Poor sanitation infrastructure is common among low to middle-income countries and neighborhoods. Only 39% of the world population is served by 'safely managed' sanitation while 61% of the world's population is considered hazardous.<sup>26</sup>

Differences in solid waste management in different communities are also a contributing factor in the prevalence of antibiotic resistance. Each year, 1.85 billion tons of municipal waste are produced and of that waste, 62% are produced in low-income countries and communities.<sup>26</sup> Waste disposal practices are also different in each society. Some areas practice landfills and centralized waste disposal while others engage in indiscriminate dumping.<sup>26</sup> In low-income countries, 40% of the waste is collected while 100% of the waste is collected in high-income countries.<sup>26</sup> When the waste is collected in low-income countries it is most likely to be disposed of in open dumps instead of a landfill. These differences in waste management produce

disparities in how members of society interact with solid waste. Antibiotics are a major component of solid waste that accumulates in certain environments. When antibiotics are improperly disposed of by hospitals and clinics, they can end up in solid waste that is openly dumped in the environment. Antibiotic residues can then create localized selective pressures on bacterial species that enhance antibiotic resistance.<sup>26</sup> Improving solid waste disposal can potentially limit the development and transmission of antibiotic-resistant bacteria.

Poor governance and lack of infection control are other important aspects of the emergence of resistance. The lack of antibiotic control measures creates a gap in the efforts to minimize the spread of antibiotic resistance. Certain hospitals have still not implemented the steps needed to track the dispensing rate of antibiotics, while other hospitals have not prioritized the prevention of infections which can limit the number of antibiotics that are prescribed. The majority of these cases are due to a lack of research funding by the government and limited resources.

Poor government and policy-making also play a role in the lack of infection control. Policymakers fail to establish a national action plan against antibiotic resistance. A study done in a neuro-ICU in Russia aimed to show the effectiveness of implementing an infection control and prevention program on the incidence of health-care-associated infections and antibiotic resistance.<sup>27</sup> The study included 2038 patients of all ages and both genders for six years with a focus on patients who were diagnosed with central-line associated infections, ventricular associated pneumonia, catheter-associated urinary tract infections, and hospital-related ventriculitis and meningitis (HAVM).<sup>27</sup> Data regarding the incidence of cases were collected before and after the establishment of the infection prevention and control program. Results showed that the incidence of all-cause hospital-associated infections was significantly lower for

respiratory infections (from 36.1% to 24.5%), urinary tract infections (29.07% to 21.3%), and HAVM (15.97% to 7.78%).<sup>27</sup> The implementation of the infection prevention and control program has positively impacted the reduction of hospital-associated and drug-resistant infections.

## **Discussion**

Antibiotic resistance continues to be a growing public health concern. Over time, the scientific and clinical mechanisms in which resistance develops have been established but recently researchers have found that social determinants of health have also played a major role in the prevalence of antibiotic resistance and the rise of multi-drug resistant infections. One would argue that understanding the social determinants of health is important for any public health concern including antibiotic resistance. These factors play a role in the efforts to fight resistance and improve health outcomes. Although this paper was not inclusive of all social determinants that can influence the rise of antibiotic resistance, it mainly focused on the main ones such as economics, education, culture, and lastly the environment. The literature review highlighted the importance of understanding how disparities seen in each of these categories can greatly impact the prevalence of antibiotic resistance.

The first study mentioned in this literature review outlined how patients in a small town in Ethiopia were given antibiotics for non-bacterial illnesses due to the poor economics of the healthcare facility.<sup>8</sup> This study supports the argument above in many ways. First, it supports the claim that poor economics leads hospitals to engage in poor clinical practices. The article outlined that due to the cost-saving measures of the hospitals being studied, patients were given antibiotics inappropriately. Second, it proved that the overuse of inappropriate antibiotics

negatively impacted the patients and the Yiraglem health system. However, this study did also have a few limitations. The cross-sectional study design used to obtain the results is not sufficient enough to prove the cause and effect relationship. The data collected also lacks longevity. Since the participants were given questionnaires to identify the circumstance in which they were given antibiotics, there is also some recall bias that takes place in the data collection. Although this article has limitations, it highlights the importance of economic factors in the development of antibiotic resistance.

The role of self-medication was also discussed in the literature review to further support the idea that income, poverty, and lack of access to healthcare can lead to inappropriate practices such as self-medication which propels antibiotic resistance. Macias et al, provided supporting evidence that due to a lack of health insurance and money, underserved individuals were crossing the Mexican border to obtain medications like antibiotics and analgesics.<sup>9</sup> This study had limitations as well including recall bias, and the participants were only comprised of people who attended a local health fair at the time of the study. However, the study pointed out that self-medication did not only contribute to the patients' negative health outcomes, but it continued to play a role in public health issues like antibiotic resistance. Purchasing non-prescribed antibiotics from outside countries and administering them frequently can increase the resistance rate and when individuals return to their areas of residence, they can transmit the resistant pathogens to others.

In addition, Seam et al provided results that demonstrated the role of medication cost on self-medication.<sup>12</sup> This study was used to strengthen the concept of self-medication contributing to antibiotic resistance. The location of the study further provided some context on the areas of the world where self-medication is prevalent and where healthcare funding should be directed

towards. However, the study focused on the practice of self-medication amongst pharmacy students. Further research will need to be done to prove that self-medication is a common practice seen amongst a greater number of Bangladeshi citizens.

Lastly, in the same section, the literature review also touched on the financial burden that antibiotic-resistant infections have on hospital systems. This type of burden can negatively impact healthcare facilities by limiting their resources, and possibly leading them to closure. Tabak et al compared the differences in the hospital finances between treating patients with multi-drug resistant *P. Aeruginosa* and non-multidrug resistant *P. Aeruginosa*.<sup>14</sup> This study was incorporated because it clearly illustrates how a multi-drug resistant infection can increase the hospital's expenses by thousands of dollars. This study was reliable in comparing the two variables and keeping all the other variables constant. The study emphasized the importance of identifying patients with drug-resistant infections as early as possible and taking the necessary steps needed to limit the spread of drug-resistant infections.

The literature review discussed how education is another important social determinant that can either positively or negatively influence antibiotic resistance. Poor health literacy is common in developing countries and low-income communities, and studies show that this is where health concerns like antibiotic resistance are most concentrated. Understanding the role of antibiotics in the treatment of infection is crucial for limiting resistance. If individuals are not well rehearsed on the clinical components of antibiotics such as the mechanism of action, indications, side effects, duration of therapy, and the species they treat, it is very difficult for them to understand the concept of resistance and how it can develop. Antibiotic education is the primary tool in the fight against resistance. It is important for both the general public and medical providers to gain this knowledge.

Barah et al conducted a study in Kalamoon, the Syrian Arab Republic to determine the role of knowledge in the misuse of antibiotics.<sup>17</sup> The study had a compelling sample size and well-displayed data. With the results of the study stated above, it concluded that the misuse of antibiotics seen in this region was due to a lack of awareness of the appropriate use of antibiotics and their potential dangers. The study determined that for this region to see any improvement, major educational reforms needed to be implemented such as better patient education, public information campaigns, and stricter laws on antibiotic prescribing.<sup>17</sup> It can be predicted that with the establishment of these practices in Kalamoon, and many other countries where antibiotic education is scarce, antibiotic resistance can be greatly reduced.

Antibiotic misuse is another indication that lack of knowledge can steer inappropriate medical practices. Al Ghamdi et al provided evidence that after a thorough investigation, a 174-bed hospital in Saudi Arabia was dispensing prophylactic and therapeutic antibiotics inappropriately to admitted patients.<sup>18</sup> This was a prospective study conducted over six months. The study was well-conducted and had a great sample size. However, the study lacked further analysis on all the possible reasons for antibiotic misuse.

Furthermore, misinformation can add to the act of misusing antibiotics. When individuals are not taught about the proper indications for antibiotics and how to use them appropriately, they often rely on hearsay from the people around them. This can lead to the possible spread of false information. When false information is spread, it can be difficult to reconstruct an individual's viewpoint. Over time, medical providers have been faced with the issue of patients requesting antibiotics for non-bacterial illnesses such as the cold or flu because they believe antibiotics are meant to treat all illnesses. This has caused a strain on patient-provider

relationships. Educating individuals on antibiotics is vital for reducing the spread of misinformation and it can help relieve some of the burden placed on medical providers.

Cultural beliefs and practices are other social determinants of antibiotic misuse. Similar to the concept of misinformation, when individuals are not properly educated on certain topics, they often look to those they trust such as family members, priests, and members of the community for information and guidance. Moreover, they trust those whom they share characteristics with such as language, skin color, ethnicity, race, etc. Over time, sharing of information amongst a certain group becomes an established belief in a culture or society. Clinicians have seen this concept occur in terms of antibiotic usage. Watkins et al showed how this concept was practiced amongst Hispanics in the United States.<sup>20</sup> The article included results that compared the view of antibiotic usage between Hispanics and non-Hispanics. The results were very helpful in understanding how cultural differences can make an impact on how individuals perceive antibiotics. Culture is an important part of human development and interaction. Medical providers must take into account cultural differences when educating patients on topics like antibiotic resistance and many others.

Over-prescription of antibiotics should also be evaluated when investigating antibiotic resistance. Ramachadran et al compared the antibiotic over-prescription rate between two groups of dental students with different levels of education in India.<sup>22</sup> This was another cross-sectional study that cannot properly prove a cause-and-effect relationship. However, the study provided decent results and a great analysis of the possible reasons for the differences seen between the two groups. It proved that education, although not the only factor, can contribute to the overprescribing of antibiotics, thus adding to resistance. The researchers gathered that in order to improve resistance, hospitals and schools need to improve the educational value of antibiotic

prescription, conduct regular review meetings & discussions, and provide feedback and monitoring on antibiotic resistance.<sup>22</sup>

The environmental aspect of the development and spread of antibiotic resistance is evaluated in the literature review to conclude the discussion of social determinants of antibiotic resistance and bring the research closer to answering the PICO question stated in the introduction. Environmental aspects of antibiotic resistance include but are not limited to urban living, crowded housing and facilities, poor infrastructure, waste disposal, and lack of infection control. The social and economic disparities seen in these topics further prove the argument that social determinants can affect antibiotic resistance. The environments in which individuals reside in can impact their health either positively or negatively. Unfortunately, there are many areas in the world where poor infrastructure leads to a variety of illnesses including multi-drug resistant infections. Without the proper sanitation of water, soil, and food antibiotic resistance can easily spread. In addition, poor management of waste disposal can create environments where resistant pathogens develop. In the absence of sanitation and proper infrastructure, countries cannot eradicate antibiotic resistance. Infection control programs are also needed to prevent the rise of multi-drug resistant infections and monitor the emergence of antibiotic resistance. Surveillance programs need to be established in areas where antibiotic resistance is high in order to improve this global concern.

All of these articles have provided the groundwork and evidence that are needed to answer the PICO question and strengthen the argument on the impact of social determinants on antibiotic resistance. Although the studies had their limitations, they all provided results that help support the answer to the PICO question. The studies proved that understanding the social determinants of antibiotic resistance is one of the most important ways to fight this global issue.



Recognizing the social and economic factors that precipitate resistance is not only helpful in reducing resistance but is also helpful in appreciating the importance of preventive medicine. Many of these factors that contribute to resistance can be improved if policymakers and health systems pour more public health efforts into prevention strategies. This includes making healthcare more accessible, reducing the costs of medicine, improving patient education, increasing antibiotic education in school, introducing public health campaigns, improving sanitation and waste disposal, and implementing infection control and surveillance programs. All of these efforts can make dramatic impacts in the reduction of antibiotic resistance, especially in underserved communities.

## **Conclusion**

In conclusion, this paper was written to answer the question: Can socioeconomic factors play a role in the prevalence of antibiotic resistance? The paper begins by providing a historical context on how antibiotic resistance became a global health issue and introduces the concept of social determinants of health. Then, it proceeds into a literature review on articles that aim to answer the PICO question stated above.

After conducting the literature review, one can conclude that socioeconomic factors can indeed have an impact on both the development and spread of antibiotic resistance. The articles that were analyzed demonstrate the role of economics, education, culture, and the environment on antibiotic resistance. The evidence provided in these articles was statistically and clinically significant and they all comprehensively reject the null hypothesis. This specific area of research is important to explore because it is often ignored or swept under the rug. Understanding the social determinants of health is very important for improving the health care system and an

individuals' overall quality of life. Without addressing these concerns, individuals cannot see the bigger picture and therefore, act accordingly. More importantly, understanding these social factors of antibiotic resistance can fuel more scientific research and educational innovations that aim to prevent the occurrence of resistant pathogens and improve the quality of antibiotics. Due to the limitations of the studies used, further research will need to be conducted that can prove the cause-of-effect relationship between socioeconomic factors and antibiotic resistance with the emphasis on improved study designs, reduction of bias, and results collected over a longer period. Antibiotic resistance has been an everlasting issue in the United States and many parts of the world, and it continues to increase every day. The solution lies in the continuous awareness and education surrounding the factors that are related to the foundation of this issue including socioeconomic determinants of health. If countries continue to improve these factors, antibiotic resistance can ultimately become a much lesser threat to healthcare.

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