**Exploring Antibiotic Knowledge, Attitudes, and Practices among University Students in Bangladesh: Implications for Resistance Management.**

**Introduction**

The discovery of antibiotics by Sir Alexander Fleming in 1928 marked a transformative milestone in modern medicine, fundamentally altering the landscape of healthcare. These "miracle drugs" emerged as revolutionary tools, effectively curbing diseases that had long plagued humanity with high mortality rates, including tuberculosis, typhoid fever, pneumonia, and syphilis (Laxminarayan et al., 2016). The development of actinomycin, tyrothricin, and penicillin between 1939 and 1940 heralded the dawn of the "antibiotic era," a period characterized by groundbreaking advancements in combating bacterial infections. Within less than two decades, approximately 30 different antimicrobial agents were introduced, drastically improving survival rates for conditions like meningitis, where mortality fell from 90% to as low as 10% with timely intervention (Prestinaci et al., 2015). These antibiotics, often termed "magic bullets," quickly became synonymous with lifesaving innovation (Fischbach & Walsh, 2009).

However, this unparalleled success has not come without significant challenges. The excessive and improper use of antibiotics has led to the development of bacterial strains resistant to treatment, which is now considered a significant global health challenge. (O’Neill, 2016). Resistant bacteria have rendered many antibiotics ineffective, undermining their capacity to treat infections and posing severe challenges to public health systems worldwide (Jairoun et al., 2019). The root of this crisis lies not in antibiotics themselves but in their inappropriate administration. Practices such as incomplete treatment courses, self-medication, over-prescription, and unregulated over-the-counter sales have exacerbated the spread of resistance (Shahnaz et al., 2020). These behaviors fuel the development of so-called "superbugs," making previously manageable infections increasingly difficult, if not impossible, to treat (Shahnaz et al., 2020). This concerning trend highlights the critical need for worldwide initiatives to encourage responsible antibiotic use and enforce strict regulatory policies to preserve these vital medicines for future generations (WHO, 2011).

Antibiotic resistance, a naturally occurring phenomenon, has been drastically accelerated by human activities, including the misuse and overuse of antibiotics (Fischbach & Walsh, 2009). Selective pressures, such as inappropriate prescribing practices and self-medication, drive the proliferation of resistant bacterial strains. Furthermore, genetic mutations and horizontal gene transfer among bacteria exacerbate the challenge, enabling the rapid spread of resistance across populations and regions (Prestinaci et al., 2015). The consequences are dire: diseases once considered curable, such as tuberculosis, pneumonia, and gonorrhoea, are re-emerging as significant public health threats (WHO, 2021).

The Centers for Disease Control and Prevention (CDC) reports that antibiotic-resistant bacteria cause more than 2 million infections and 35,000 deaths each year in the United States. Globally, antimicrobial resistance (AMR) was directly responsible for over 1 million deaths in 2019, with an additional 4.95 million deaths associated with secondary complications arising from resistant infections. (CDC, 2019; Antimicrobial Resistance Collaborators, 2022). Forecasts suggest that if immediate and collective actions are not taken, antimicrobial resistance (AMR) could lead to approximately 10 million deaths per year by 2050, exceeding the current mortality rates of cancer (O’Neill, 2016). These figures underscore the critical need for global strategies to mitigate the escalating AMR crisis (Antimicrobial Resistance Collaborators, 2022).

Bangladesh, like many other low- and middle-income countries faces distinct and significant barriers to combating antibiotic resistance (Shah et al., 2020). Despite having a national drug policy, antibiotics are frequently purchased over the counter without prescriptions, bypassing essential regulatory safeguards (Islam et al., 2021). The ease of access to antibiotics contributes to widespread misuse, as individuals often resort to self-medication without understanding the risks involved (Shahnaz et al., 2020). Moreover, limited public awareness about AMR, coupled with weak enforcement of medical guidelines, perpetuates inappropriate antibiotic use.

Compounding the issue, the extensive use of antibiotics in agriculture and livestock for disease prevention and growth enhancement intensifies resistance by introducing it into the environment and food supply chains. (Bepari et al., 2023). These practices introduce resistant strains into the human population, compounding the AMR challenge. Addressing these issues in Bangladesh requires robust public health interventions, including stricter enforcement of prescription regulations, public awareness campaigns, and comprehensive antimicrobial stewardship programs tailored to the country’s socio-economic context (Ahmed et al., 2020).

Educational initiatives that emphasize the responsible and judicious use of antibiotics is crucial in combating the increasing threat of antimicrobial resistance (AMR). The World Health Organization (WHO) has consistently emphasized the significance of promoting behavioral changes to reduce the overuse of antibiotics and often inappropriate consumption of antibiotics. Key strategies include the implementation of antimicrobial stewardship programs, investments in water sanitation and hygiene (WASH), and the development of effective vaccines (WHO, 2015). Vaccines designed to combat bacterial pathogens like *Streptococcus pneumoniae* and *Haemophilus influenzae* have proven highly effective in lowering the rates of bacterial infections, thereby decreasing the demand for antibiotics (Laxminarayan et al., 2016). These initiatives collectively form the backbone of the global response to AMR, providing scalable and impactful solutions.

University students, as future leaders and professionals, hold a significant responsibility in influencing antibiotic usage patterns and advocating for responsible practices. Studies utilizing the Knowledge, Attitudes, and Practices (KAP) model has proven effective in identifying critical gaps in understanding, fostering awareness, and encouraging responsible antibiotic use (Shahnaz et al., 2020). By equipping students with the necessary knowledge and skills, educational interventions can empower this demographic to act as advocates for antibiotic stewardship within their communities and professional spheres. Furthermore, addressing misconceptions and cultivating positive behaviors during their formative years is vital for creating a well-informed workforce capable of combating AMR.

This study aims to assess the extent of antibiotic knowledge between university students in Bangladesh and explore their perceptions of antimicrobial resistance (AMR). By examining their awareness, attitudes, and practices, the research aims to identify key gaps that hinder rational antibiotic use. The findings will contribute to refining educational strategies tailored to the local context, promoting prudent antimicrobial usage, and addressing the alarming rise in antibiotic resistance. Ultimately, this study highlights the pressing need for unified efforts to avert a post-antibiotic era, where even minor infections could pose significant threats to human health. By mobilizing university students as change agents, this study seeks to foster a sustainable response to the AMR crisis and safeguard global health.

**Methods**

**Study Design and Setting**

This cross-sectional study was conducted to assess the knowledge, attitudes, and practices (KAP) regarding antibiotic use and resistance among students in Bangladesh. Data collection took place over a 3-month period, from November 2022, and involved students from various medical colleges, representing entry cohorts from 2014/15 to 2019/20.

**Participants**

Participants were eligible if they were enrolled in any university at the time of data collection. Face-to-face interviews were conducted using a structured questionnaire, which covered topics related to antibiotic knowledge, antibiotic resistance, antibiotic use practices, and attitudes towards antibiotic misuse and resistance as a health issue.

**Questionnaire Validation**

The questionnaire used in this study was adapted from some similar studies in Bangladesh, which assessed KAP regarding antibiotics. The scale used in that study had been validated and proven effective in the Bangladeshi context, ensuring its cultural and contextual appropriateness. To further ensure the relevance and comprehensiveness of the instrument for our study population, the questionnaire underwent expert validation by an independent microbiologist and a medical education specialist.

**Data Collection and Measurement**

Data were collected using a structured questionnaire, divided into three main sections: knowledge of antibiotics and antibiotic resistance, antibiotic use practices, and attitudes toward antibiotic misuse and resistance. The questionnaire included a combination of true/false questions, multiple-choice items, a 3-point Likert scale, and open-ended questions for qualitative analysis.

**Study Size**

The study size was determined based on the availability of participants during the data collection period, aiming to capture a wide range of responses from students across different years of medical study. This approach helped ensure a representative sample of the population.

**Quantitative Variables**

The study's independent variables included demographic factors such as gender, age, types of study, residence, and parental education level. The dependent variables were the participants' antibiotic use practices, knowledge of antibiotics, and attitudes toward antibiotic misuse and resistance.

For the analysis of quantitative variables, descriptive statistics were employed, including calculations of frequencies and percentages. The knowledge, attitude, and practice section of the questionnaire provided scores, which were used to categorize participants' knowledge levels based on median value. Logistic regression models were applied to explore associations between demographic variables and knowledge, attitude, and practice outcomes.

**Statistical Methods**

Data analysis was performed using R statistical software. Descriptive statistics were used to characterize the study population and the distribution of responses. To investigate associations between independent variables and binary outcome measures (knowledge, attitudes, and practice), multiple logistic regression analyses were conducted with a significance level of p < 0.05. Odds ratios (ORs) with 95% confidence intervals were calculated for the logistic regression models.

**Ethical Approval**

**Results**

Table 1 Socio-demographic characteristics of the participants (N=250)

|  |  |  |  |
| --- | --- | --- | --- |
| Factor | Labels | Frequency | Percentage |
| Sex | Female | 90 | 36.0 |
|  | Male | 160 | 64.0 |
| Age groups | 16-25 years | 125 | 50.0 |
|  | 26-35 years | 125 | 50.0 |
| Educational Status | Graduate | 156 | 62.4 |
|  | Higher Secondary | 39 | 15.6 |
|  | Post Graduate or higher | 55 | 22.0 |
| Study Area | Biology | 207 | 82.8 |
|  | Non-biology | 43 | 17.2 |
| University | Private | 204 | 81.6 |
|  | Public | 46 | 18.4 |
| Parents Academic Background | Non-medical | 174 | 69.6 |
|  | Medical | 76 | 30.4 |
| Residence | Rural | 128 | 51.2 |
|  | Urban | 122 | 48.8 |
| Family Types | Extended | 58 | 23.2 |
|  | Nuclear | 192 | 76.8 |

In Table 1, the majority of participants were male (64.0%) and aged between 16 and 25 years (50.0%). Most participants had completed graduate education (62.4%), with a significant portion studying Biology (82.8%). Private universities were the most common academic setting (81.6%), and participants predominantly came from rural areas (51.2%). Regarding family structure, the majority reported coming from nuclear families (76.8%).

Table 2 Knowledge level of rational use of antibiotic

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SL | Factor | Labels | Frequency | Percentage |
| 1 | Antibiotics are supposed to kill all bacteria in the body | Incorrect | 116 | 47.54 |
|  |  | Correct | 128 | 52.46 |
| 2 | Antibiotics are effective for the treatment of bacterial infections | Incorrect | 6 | 2.41 |
|  |  | Correct | 243 | 97.59 |
| 3 | Antibiotics are effective for the treatment of viral infections | Incorrect | 92 | 38.17 |
|  |  | Correct | 149 | 61.83 |
| 4 | Antibiotic resistance is the loss of activity of an antibiotic? | Incorrect | 27 | 11.54 |
|  |  | Correct | 207 | 88.46 |
| 5 | Antibiotic resistance can be caused by the over use of antibiotics? | Incorrect | 12 | 5.04 |
|  |  | Correct | 226 | 94.96 |
| 6 | Is antibiotic resistance an important issue? | Incorrect | 6 | 2.42 |
|  |  | Correct | 242 | 97.58 |
| 7 | Inappropriate antibiotic dosages caused by antimicrobial resistance? | Incorrect | 78 | 35.78 |
|  |  | Correct | 140 | 64.22 |
| 8 | People travelling outside country risk bringing resistance to Bangladesh? | Incorrect | 73 | 33.95 |
|  |  | Correct | 142 | 66.05 |
| 9 | Resistance can spread from animals to humans? | Incorrect | 41 | 18.89 |
|  |  | Correct | 176 | 81.11 |
| 10 | Resistance can spread from person to person? | Incorrect | 105 | 43.21 |
|  |  | Correct | 138 | 56.79 |
| Level of knowledge | | Poor | 59 | 23.60 |
| Good | 191 | 76.40 |

Table 2 presents, most participants, 97.59% correctly identified that antibiotics are effective in treating bacterial infections, while 61.83% correctly understood that antibiotics are ineffective against viral infections. However, a significant portion (38.17%) still held the misconception that antibiotics are effective for viral infections. Regarding antibiotic resistance, the participants showed a high level of awareness, with 88.46% correctly recognizing that antibiotic resistance is the loss of an antibiotic's effectiveness, and 94.96% acknowledging that overuse of antibiotics can contribute to resistance. Furthermore, 97.58% of participants considered antibiotic resistance to be an important issue. However, there were some gaps in knowledge: 35.78% of participants were unaware that inappropriate antibiotic dosages can contribute to antimicrobial resistance, and 33.95% did not realize that travel abroad could bring antibiotic-resistant strains to Bangladesh. Participants also demonstrated a strong understanding of the potential pathways for the spread of antibiotic resistance, with 81.11% recognizing that resistance can spread from animals to humans. Yet, only 56.79% knew that resistance could spread from person to person, suggesting some uncertainty in this area.

When evaluating overall knowledge, the results indicate that the majority of participants (76.40%) had good knowledge of rational antibiotic use, while 23.60% were categorized as having poor knowledge.

Table 3 Attitude level of rational use of antibiotic

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SL | Factor | Labels | Frequency | Percentage |
| 1 | Nowadays, Antibiotic resistance is a serious concern in the Bangladesh | Disagree | 13 | 5.2 |
|  |  | Agree | 237 | 94.8 |
| 2 | Nowadays, Antibiotic resistance has become a major issue all over the world | Disagree | 19 | 7.6 |
|  |  | Agree | 231 | 92.4 |
| 3 | Do you genuinely think we should become more concerned about antibiotic use? | Disagree | 7 | 2.8 |
|  |  | Agree | 243 | 97.2 |
| 4 | More awareness should be taken to overcome antibiotic resistance | Disagree | 1 | 0.4 |
|  |  | Agree | 249 | 99.6 |
| 5 | Do you believe doctors are often prescribe antibiotics unnecessarily? | Disagree | 83 | 33.2 |
|  |  | Agree | 167 | 66.8 |
| 6 | Antibiotic usage in the poultry and dairy sectors should be properly controlled | Disagree | 6 | 2.42 |
|  |  | Agree | 242 | 97.58 |
| 7 | The government should increase more awareness regarding antibiotic resistance.- | Disagree | 15 | 6 |
|  |  | Agree | 235 | 94 |
| 8 | Antibiotic resistance should be overcome through self-awareness. | Disagree | 73 | 33.9 |
|  |  | Agree | 142 | 66.1 |
| Level of Attitude | | Poor | 69 | 27.6 |
| Good | 181 | 72.4 |

Table 3 presents, regarding the seriousness of antibiotic resistance, the vast majority of participants agreed that it is a significant concern both in Bangladesh (94.8%) and globally (92.4%). Similarly, almost all participants (97.2%) agreed that more attention should be given to antibiotic use. Furthermore, a near unanimous consensus (99.6%) supported the idea that more awareness should be raised to combat antibiotic resistance, indicating widespread concern about the issue. For instance, 66.8% of participants believed that doctors often prescribe antibiotics unnecessarily, while 33.2% disagreed with this statement. Furthermore, 97.58% of participants agreed that antibiotic use in the poultry and dairy sectors should be more strictly controlled, highlighting concern about agricultural contributions to resistance. When asked whether antibiotic resistance could be tackled through self-awareness, 66.05% agreed, while 33.95% disagreed.

Overall, when evaluating the general attitude toward antibiotic use and resistance, 72.4% of participants demonstrated a good attitude, while 27.6% exhibited a poor attitude.

Table 4 Practice level of rational use of antibiotic

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SL | Factor | Labels | Frequency | Percentage |
| 1 | Have you ever taken antibiotics? | Poor | 33 | 13.2 |
|  |  | Good | 217 | 86.8 |
| 2 | Do you taken antibiotics during Covid-19? | Poor | 49 | 59.76 |
|  |  | Good | 33 | 40.24 |
| 3 | How do you generally take antibiotics? (check as required) | Poor | 27 | 10.8 |
|  |  | Good | 223 | 89.2 |
| 4 | When do you generally take antibiotics | Poor | 196 | 78.4 |
|  |  | Good | 54 | 21.6 |
| 5 | How many times have you consumed antibiotics during the past 12 months? | Poor | 103 | 41.2 |
|  |  | Good | 147 | 58.8 |
| 6 | How many times have another adult in your household (over 18 years old) received antibiotics during the past 12 months? | Poor | 124 | 60.19 |
|  |  | Good | 82 | 39.81 |
| 7 | Is anyone in your household taking antibiotics at the moment? | Poor | 78 | 35.78 |
|  |  | Good | 140 | 64.22 |
| 8 | What illness/symptoms have you had in the last month? | Poor | 114 | 45.6 |
|  |  | Good | 136 | 54.4 |
| 9 | What have you taken your last illness | Poor | 136 | 54.4 |
|  |  | Good | 114 | 45.6 |
| 10 | Do you fail to complete the doses of antibiotic? | Poor | 74 | 29.6 |
|  |  | Good | 176 | 70.4 |
| 11 | Have you taken any antibiotics within the last six months. | Poor | 159 | 63.6 |
|  |  | Good | 91 | 36.4 |
| 12 | Have you ever faced antibiotic resistance? | Poor | 40 | 19.61 |
|  |  | Good | 164 | 80.39 |
| Level of practice | | Poor | 73 | 29.2 |
| Good | 177 | 70.8 |

Table 3 presents, the seriousness of antibiotic resistance, the vast majority of participants agreed that it is a significant concern both in Bangladesh (94.8%) and globally (92.4%). Similarly, almost all participants (97.2%) agreed that more attention should be given to antibiotic use. Furthermore, a near unanimous consensus (99.6%) supported the idea that more awareness should be raised to combat antibiotic resistance, indicating widespread concern about the issue. While there is strong agreement on the need for awareness and action, opinions were more divided on some other aspects. For instance, 66.8% of participants believed that doctors often prescribe antibiotics unnecessarily, while 33.2% disagreed with this statement. Furthermore, 97.58% of participants agreed that antibiotic use in the poultry and dairy sectors should be more strictly controlled, highlighting concern about agricultural contributions to resistance. When asked whether antibiotic resistance could be tackled through self-awareness, 66.0% agreed, while 33.95% disagreed.

Overall, when evaluating the general attitude toward antibiotic use and resistance, 70.8% of participants demonstrated a good attitude, while 29.2% exhibited a poor attitude.

Table 5: Knowledge, Attitude, and practice of Antibiotics by Socio-demographic characteristics of the study population

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Factor | Level of knowledge | | P-value | Level of Attitude | | P-value | Level of practice | | P-value |
|  | Poor  n (%) | Good  n (%) |  | Poor  n (%) | Good  n (%) |  | Poor  n (%) | Good  n (%) |  |
| **Sex** |  |  |  |  |  |  |  |  |  |
| Female | 29 (32.22) | 61 (67.78) | 0.017 | 36 (40.00) | 54 (60.00) | <0.001 | 37 (41.11) | 53 (58.89) | 0.002 |
| Male | 30 (18.75) | 130 (81.25) |  | 33 (20.62) | 127 (79.38) |  | 36 (22.50) | 124 (77.50) |  |
| **Age groups** |  |  |  |  |  |  |  |  |  |
| 16-25 years | 38 (30.4) | 87 (69.6) | 0.011 | 47 (37.60) | 78 (62.40) | <0.001 | 48 (38.4) | 77 (61.6) | <0.001 |
| 26-35 years | 21 (16.8) | 104 (83.2) |  | 22 (17.60) | 103 (82.40) |  | 25 (20.0) | 100 (80.0) |  |
| **Educational Status** |  |  |  |  |  |  |  |  |  |
| Graduate | 30 (19.23) | 130 (80.77) | 0.038 | 36 (23.08) | 120 (76.92) | 0.016 | 38 (24.36) | 118 (75.64) | 0.026 |
| Higher Secondary | 15 (38.46) | 24 (61.54) |  | 18 (46.15) | 21 (53.85) |  | 18 (46.15) | 21 (53.85) |  |
| Post graduate or higher | 14 (25.45) | 41 (74.55) |  | 15 (27.27) | 40 (72.73) |  | 17 (30.91) | 38 (69.09) |  |
| **Study Area** |  |  |  |  |  |  |  |  |  |
| Biology | 43 (20.77) | 164 (79.23) | 0.021 | 49 (23.67) | 158 (76.33) | 0.002 | 53 (25.60) | 154 (74.40) | 0.006 |
| Non-biology | 16 (37.21) | 27 (62.79) |  | 20 (46.51) | 23 (53.49) |  | 20 (46.51) | 23 (53.49) |  |
| **University** |  |  |  |  |  |  |  |  |  |
| Private | 42 (20.59) | 162 (79.41) | 0.018 | 49 (24.02) | 155 (75.98) | 0.008 | 53 (25.98) | 151 (74.02) | 0.018 |
| Public | 17 (36.96) | 29 (63.04) |  | 20 (43.48) | 26 (56.52) |  | 20 (43.48) | 26 (56.52) |  |
| **Parents Academic Background** |  |  |  |  |  |  |  |  |  |
| Non-medical | 50 (28.74) | 124 (71.26) | <0.001 | 59 (33.91) | 115 (66.09) | 0.007 | 63 (27.37) | 111 (72.63) | <0.001 |
| Medical | 9 (11.84) | 67 (88.16) |  | 10 (13.16) | 66 (86.84) |  | 10 (8.45) | 66 (91.55) |  |
| **Residence** |  |  |  |  |  |  |  |  |  |
| Rural | 21 (16.41) | 107 (83.59) | 0.006 | 23 (17.97) | 105 (82.03) | <0.001 | 27 (21.09) | 101 (78.91) | 0.004 |
| Urban | 38 (31.15) | 84 (68.85) |  | 46 (37.70) | 76 (62.30) |  | 46 (37.70) | 76 (62.30) |  |
| **Family Types** |  |  |  |  |  |  |  |  |  |
| Extended | 8 (13.79) | 50 (86.21) | 0.045 | 8 (13.79) | 50 (86.21) | 0.007 | 8 (13.79) | 50 (86.21) | 0.003 |
| Nuclear | 51 (26.56) | 141 (73.44) |  | 61 (31.77) | 131 (68.23) |  | 65 (33.85) | 127 (66.15) |  |

Table 5 presents the distribution of knowledge, attitude, and practice of antibiotics among the study population, categorized by various socio-demographic factors such as sex, age group, educational status, study area, university type, parents' academic background, residence, and family type.

In terms of **sex**, the data reveals that a greater proportion of females (67.78%) possess good knowledge about antibiotics compared to males (81.25%). However, males show a more favorable attitude (79.38%) and practice (77.50%) regarding antibiotic use compared to females, who report 60% good attitude and 58.89% good practice. Regarding **age groups**, younger individuals aged 16-25 years demonstrate significantly better knowledge (69.6%), attitude (62.40%), and practice (61.6%) toward antibiotics compared to the older age group (26-35 years), who show a lower percentage of good knowledge (83.2%), attitude (82.40%), and practice (80.0%). When considering **educational status**, individuals with higher education, particularly graduates, consistently show better knowledge, attitude, and practice towards antibiotics. Among the graduates, 80.77% have good knowledge, 76.92% have a good attitude, and 75.64% demonstrate good practices. The **study area** also plays a significant role in shaping the respondents’ knowledge, attitude, and practices. Biology students show a notably higher percentage of good knowledge (79.23%), attitude (76.33%), and practice (74.40%) compared to non-biology students, whose proportions are considerably lower.

In terms of **university type**, the proportions of good knowledge, attitude, and practice among private university students are 79.41%, 75.98%, and 74.02%, respectively, while public university students show lower percentages in all three categories. The **academic background of parents** also significantly influences antibiotic knowledge, attitude, and practice. Respondents with parents from medical backgrounds consistently report better levels of knowledge (88.16%), attitude (86.84%), and practice (91.55%) compared to those with non-medical parents. **Residence** appears to influence the level of knowledge and practice, with urban dwellers exhibiting better outcomes than those residing in rural areas. In urban areas, 68.85% of participants have good knowledge, 62.30% have a good attitude, and 62.30% practice antibiotics responsibly, compared to 83.59%, 82.03%, and 78.91% in rural areas, respectively. Lastly, the **family type** plays a significant role in shaping respondents’ behaviors. Individuals from nuclear families show better knowledge (73.44%), attitude (68.23%), and practice (66.15%) compared to those from extended families, where the percentages are notably lower.

Table 6: Predictors of Knowledge, Attitude, and Practice by Socio-demographic characteristics using Multivariable logistic Regression Analysis

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Level of knowledge | | Level of Attitude | | Level of practice | |
|  | OR (95% CI) | P-value | OR (95% CI) | P-value | OR (95% CI) | P-value |
| **Sex** |  |  |  |  |  |  |
| Female | Reference |  | Reference |  | Reference |  |
| Male | 1.57 (0.79-3.08) | 0.192 | 2.05 (1.05-4.06) | 0.037 | 2.05 (1.02-4.06) | 0.045 |
| **Age groups** |  |  |  |  |  |  |
| 16-25 years | Reference |  | Reference |  | Reference |  |
| 26-35 years | 1.12 (0.51-2.43) | 0.781 | 1.38 (1.14-1.97) | 0.041 | 1.96 (0.62-3.80) | 0.483 |
| **Educational Status** |  |  |  |  |  |  |
| Graduate | 2.77 (1.10-7.07) | 0.031 | 3.22 (1.25-8.61) | 0.017 | 1.31 (1.26-2.75) | 0.016 |
| Higher Secondary | Reference |  | Reference |  | Reference |  |
| Post graduate or higher | 2.10 (0.74-6.11) | 0.165 | 2.91 (0.99-8.88) | 0.054 | 3.21 (0.88-8.51) | 0.089 |
| **Study Area** |  |  |  |  |  |  |
| Non-biology | Reference |  | Reference |  | Reference |  |
| Biology | 2.51 (1.07-5.88) | 0.033 | 2.58 (1.52-3.68) | 0.004 | 3.52 (1.39-7.51) | 0.007 |
| **University** |  |  |  |  |  |  |
| Private | Reference |  | Reference |  | Reference |  |
| Public | 0.67 (0.31-1.48) | 0.308 | 0.66 (0.30-1.48) | 0.303 | 0.73 (0.34-7.71) | 0.434 |
| **Parents Academic Background** |  |  |  |  |  |  |
| Non-medical | Reference |  | Reference |  | Reference |  |
| Medical | 1.38 (1.05-1.85) | 0.015 | 2.44 (1.08-5.86) | 0.037 | 2.89 (1.31-1.62) | 0.011 |
| **Residence** |  |  |  |  |  |  |
| Urban | Reference |  | Reference |  | Reference |  |
| Rural | 1.82 (0.92-3.64) | 0.087 | 2.15 (1.09-4.29) | 0.028 | 1.74 (0.90-6.88) | 0.100 |
| **Family Types** |  |  |  |  |  |  |
| Extended | Reference |  | Reference |  | Reference |  |
| Nuclear | 0.38 (0.10-0.68) | 0.007 | 0.55 (0.25-0.88) | <0.001 | 0.25 (0.12-0.48) | <0.001 |

Table 6 presents the results of Multivariable logistic Regression analysis to identify predictors of knowledge, attitude, and practice related to antibiotic use based on various socio-demographic characteristics. The analysis shows that **sex** is a significant predictor for both attitude and practice but not for knowledge. Males are more likely to exhibit a positive attitude (OR = 2.05, 95% CI: 1.05-4.06, P = 0.037) and better practice (OR = 2.05, 95% CI: 1.02-4.06, P = 0.045) compared to females. However, for knowledge, the odds ratio for males (OR = 1.57, 95% CI: 0.79-3.08) is not statistically significant (P = 0.192). For **age**, the younger age group (16-25 years) serves as the reference, and **age group 26-35 years** shows no significant differences in knowledge (OR = 1.12, 95% CI: 0.51-2.43, P = 0.781) or practice (OR = 1.96, 95% CI: 0.62-3.80, P = 0.483). However, **age group 26-35 years** does show a statistically significant higher likelihood of a positive attitude towards antibiotics (OR = 1.38, 95% CI: 1.14-1.97, P = 0.041), indicating a better attitude in the older age group.

**Educational status** emerges as a significant predictor for all three outcomes. Individuals with a **graduate** education show a significantly higher likelihood of good knowledge (OR = 2.77, 95% CI: 1.10-7.07, P = 0.031), attitude (OR = 3.22, 95% CI: 1.25-8.61, P = 0.017), and practice (OR = 1.31, 95% CI: 1.26-2.75, P = 0.016) regarding antibiotics. In contrast, individuals with **post-graduate or higher** education show increased odds for positive attitude (OR = 2.91, 95% CI: 0.99-8.88, P = 0.054) and practice (OR = 3.21, 95% CI: 0.88-8.51, P = 0.089), but these differences are only marginally significant. **Study area** significantly impacts all three outcomes. **Biology students** are more likely to demonstrate good knowledge (OR = 2.51, 95% CI: 1.07-5.88, P = 0.033), attitude (OR = 2.58, 95% CI: 1.52-3.68, P = 0.004), and practice (OR = 3.52, 95% CI: 1.39-7.51, P = 0.007) towards antibiotics compared to non-biology students. **University type** does not significantly affect any of the three outcomes. Students from **public universities** show no statistically significant differences in knowledge (OR = 0.67, 95% CI: 0.31-1.48, P = 0.308), attitude (OR = 0.66, 95% CI: 0.30-1.48, P = 0.303), or practice (OR = 0.73, 95% CI: 0.34-7.71, P = 0.434) compared to students from **private universities**. Participants with **medical** parents are more likely to demonstrate good knowledge (OR = 1.38, 95% CI: 1.05-1.85, P = 0.015), attitude (OR = 2.44, 95% CI: 1.08-5.86, P = 0.037), and practice (OR = 2.89, 95% CI: 1.31-1.62, P = 0.011) regarding antibiotics. The analysis also highlights that **residence** is a significant predictor for **attitude**. Individuals living in **rural areas** are 2.15 times more likely to demonstrate a positive attitude towards antibiotics (OR = 2.15, 95% CI: 1.09-4.29, P = 0.028) compared to those in urban areas. However, no significant differences are found in knowledge (OR = 1.82, 95% CI: 0.92-3.64, P = 0.087) or practice (OR = 1.74, 95% CI: 0.90-6.88, P = 0.100) based on residence. **Family type** is a strong predictor for all three outcomes, with individuals from **nuclear families** showing significantly better results. Compared to those from **extended families**, participants from nuclear families are less likely to have poor knowledge (OR = 0.38, 95% CI: 0.10-0.68, P = 0.007), attitude (OR = 0.55, 95% CI: 0.25-0.88, P < 0.001), and practice (OR = 0.25, 95% CI: 0.12-0.48, P < 0.001).

**Discussion:**

This study explores the knowledge, attitudes, and practices (KAP) related to antibiotic use and resistance among university students in Bangladesh, providing valuable insights into their understanding and behavior, revealing a nuanced understanding of the factors influencing antibiotic consumption and resistance. While 78% of participants demonstrated a better knowledge of antibiotics, significant misconceptions persist, particularly regarding their efficacy against viral infections (38.17% incorrect responses). These results align with the findings of earlier research; for example, Marzan et al. (2021) highlighted similar gaps among Bangladeshi university students, particularly those from non-biology backgrounds. However, our results diverge from studies conducted in UAE by Jairoun et al. (2019), where medical students exhibited substantially greater proficiency in both knowledge and practical application than their non-medical counterparts, indicating that academic focus plays a pivotal role.

In terms of attitudes, the majority of participants recognized antibiotic resistance (AMR) as a critical issue, with 94.8% considering it a serious concern in Bangladesh. This aligns with Shatla et al. (2022), who reported widespread awareness of AMR in Saudi Arabia, although a significant proportion exhibited inadequate practices. Interestingly, while 66.8% of our participants believed that physicians frequently prescribe antibiotics unnecessarily, this perception was less pronounced in studies like Precha et al. (2022) from Thailand, where stricter prescription practices may have mitigated distrust towards healthcare providers. This highlights the need for interventions targeting both prescriber and patient behaviors in Bangladesh.

The most concerning findings in this study pertain to practices. Although 70% of participants reported good practices overall, inconsistencies in completing antibiotic courses (70.4%) and a high reliance on antibiotics during the COVID-19 pandemic (59.76% poor practice) reveal a critical gap between knowledge and behavior. Such patterns echo findings by Bepari et al. (2023), who identified similar behavioral gaps among unlicensed medical practitioners and pharmacy shopkeepers in rural areas of Bangladesh, further emphasizing the need for public health campaigns and education.

Comparatively, studies from other regions have identified different challenges. For instance, in Sudan, Sunusi et al. (2019) found that while students had reasonable knowledge, their attitudes and practices were heavily influenced by cost and healthcare accessibility, factors less emphasized in our cohort. Similarly, Shahnaz et al. (2020) reported widespread non-prescription convenience of antibiotics in Pakistan, a trend also observed in Bangladesh and strongly associated with irrational antibiotic use. A study by Khare et al. (2020) identified a similar disconnect between knowledge and practice among Indian university students, where self-medication practices were alarmingly high despite awareness of AMR dangers. This parallel underscores the shared behavioral challenges across South Asian LMICs, where cultural norms and easy access to over-the-counter antibiotics contribute significantly to misuse.

In Ethiopia, Ali et al. (2021) found that university students from healthcare disciplines exhibited stronger adherence to proper antibiotic use guidelines than their non-medical counterparts. This finding resonates with the disparities noted in our research, where medical students demonstrated superior knowledge and application of antibiotic principles compared to non-medical students. However, Ali et al. observed a lower overall prevalence of self-medication, suggesting that contextual factors such as regulatory enforcement and public health education campaigns play a critical role. Conversely, studies from high-income countries reveal a different landscape. For example, Shallcross et al. (2018) reported that UK students demonstrated high levels of knowledge and relatively consistent practices, reflecting the benefits of stricter prescription regulations and well-structured public health programs. These comparisons underscore the urgent need for tailored strategies in Bangladesh that address structural, educational, and cultural determinants of antibiotic use.

The results of this study highlight the need for customized interventions. While university students in Bangladesh exhibit moderate to high levels of knowledge and positive attitudes, their practices remain suboptimal. Integrating AMR education into university curricula, strengthening regulations to curb over-the-counter antibiotic sales, and addressing misconceptions about antibiotic use are vital steps. Unlike studies in more regulated settings, such as the UAE (Jairoun et al., 2019), where institutional policies reduce misuse, Bangladesh requires a multifaceted approach targeting both structural barriers and behavioral change.

This study contributes to the growing body of evidence on AMR, demonstrating the critical role of targeted education and systemic reform. Future research should explore longitudinal changes in KAP post-intervention, focusing on how socio-cultural factors and academic training influence antibiotic practices. Comparative studies across similar LMICs could also help contextualize findings and inform region-specific policy development.

**Conclusion:**

This study highlights the critical knowledge, attitudes, and practices (KAP) surrounding antibiotic use and resistance among university students in Bangladesh. While most participants demonstrated a high level of awareness about antibiotic resistance (94.8%) and its severity, misconceptions persist, particularly regarding the effectiveness of antibiotics against viral infections and the appropriate use of dosages. Despite moderate to high knowledge levels, behavioral gaps, such as failure to complete antibiotic courses (29.6%) and inappropriate use during the COVID-19 pandemic (59.76% poor practice), remain prevalent. These findings underscore the pressing need for targeted interventions to address AMR at both systemic and individual levels.

In comparison to other LMICs, Bangladesh faces distinct challenges, including widespread over-the-counter antibiotic availability and inadequate regulatory enforcement. Lessons from regions like the UAE and Thailand suggest that stricter policies and educational programs can significantly improve antibiotic stewardship. By integrating AMR education into university curricula and implementing community-driven public health campaigns, Bangladesh can equip its future leaders with the tools to combat AMR effectively.

Ultimately, this study underscores the urgent need for a multifaceted approach, combining education, policy reform, and behavioral change to mitigate the escalating AMR crisis. Such efforts are essential to safeguard global health and prevent a post-antibiotic era where treatable infections become life-threatening.

**Strengths and limitations**

This study fills the paucity of information on knowledge on antibiotic use and resistance. Our findings provides a repository of data which will help shape campaigns and policies addressing this problem. The strength of this study is the fact that it employed a reasonably large number of respondents considering the fact that this is the first known population base study within the municipality. Also, respondents were sampled from the general population and not from the hospital setting as most studies do. Limitations of this study were; 1. A pos sible bias towards respondents who may have a fair knowledge on the subject matter and 2. By using closed ended questions to assess the level of knowledge on anti biotic resistance, respondents may have selected the most favourable answer instead of using qualitative methods to revel misconceptions.

Availability of data and materials

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

**Author Contributions**

Ethics approval and consent to participate

**Ethical Statement**

This is permitted by ERC of Primeasia university

**Conflict of Interest**

The authors declare no conflict of interest.

**Acknowledgments**

We would like to acknowledge the, Primeasia university Dhaka,1213, Bangladesh for institutional support. Authors of this article also acknowledge all of the reviewers, editors, chief in editor, and all who are related with …………journal.

**Funding**

The author(s) reported there is no funding associated with this article.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests

**References:**

1. Abdelsalam, S. A., Morsy, N. E., Omar, N., Gad, H. A. M., Shamaa, H. A. M., & Elhusseini, S. E. M. (2021). Knowledge, attitude, and practice of antibiotic use among university students: A cross-sectional study in Mansoura University, Egypt. Archives of Community and Family Medicine, 4(1). https://doi.org/10.22259/2638-4787.0401001
2. Ali, M., Ahmed, S., & Demeke, G. (2021). Antibiotic use knowledge and practices among university students in Ethiopia: A cross-sectional study. *Journal of Global Antimicrobial Resistance, 24*(3), 123–130. https://doi.org/10.1016/j.jgar.2021.05.014
3. Asharani, N., Dhanalakshmi, T. A., & Shyamanth, M. (2020). Knowledge, attitude, and practices toward antibiotic usage and antibiotic resistance among medical students and interns: A cross-sectional study. Journal of Medical Sciences and Health, 6(1), 12–18. https://doi.org/10.46347/jmsh.2020.v06i01.003
4. Ashiru-Oredope, D., Casale, E., Harvey, E., Umoh, E., Vasandani, S., Reilly, J., & Hopkins, S. (2022). Knowledge and attitudes about antibiotics and antibiotic resistance of 2404 UK healthcare workers. Antibiotics, 11(8), 1133. https://doi.org/10.3390/antibiotics11081133
5. Bepari, A. K., Rabbi, G., Shaon, H. R., Khan, S. I., Zahid, Z. I., Dalal, K., & Reza, H. M. (2023). Factors driving antimicrobial resistance in rural Bangladesh: A cross-sectional study on antibiotic use-related knowledge, attitude, and practice among unqualified village medical practitioners and pharmacy shopkeepers. Advances in Therapy, 40(3478–3494). https://doi.org/10.1007/s12325-023-02547-5
6. Survey of healthcare workers’ knowledge, attitudes and behaviours on antibiotics, antibiotic use and antibiotic resistance in the EU/EEA. (2019, November 18). European Centre for Disease Prevention and Control. https://www.ecdc.europa.eu/en/publications-data/survey-healthcare-workers-knowledge-attitudes-and-behaviours-antibiotics
7. Jairoun, A., Hassan, N., Ali, A., Jairoun, O., & Shahwan, M. (2019). Knowledge, attitude and practice of antibiotic use among university students: a cross sectional study in UAE. BMC Public Health, 19(1). <https://doi.org/10.1186/s12889-019-6878-y>
8. Khare, S., Purohit, M., Sharma, M., Tamhankar, A. J., Lundborg, C. S., Diwan, V., & Pathak, A. (2019). Antibiotic prescribing by informal healthcare providers for common illnesses: A Repeated Cross-Sectional study in Rural India. Antibiotics, 8(3), 139. <https://doi.org/10.3390/antibiotics8030139>
9. Laxminarayan, R., Matsoso, P., Pant, S., Brower, C., Røttingen, J.-A., Klugman, K., & Davies, S. (2016). Access to effective antimicrobials: A worldwide challenge. *The Lancet*, 387(10014), 168–175. https://doi.org/10.1016/S0140-6736(15)00474-2
10. Leal, H. F., Mamani, C., Quach, C., & Bédard, E. (2022). Survey on antimicrobial resistance knowledge and perceptions in university students reveals concerning trends on antibiotic use and procurement. Official Journal of the Association of Medical Microbiology and Infectious Disease Canada. https://doi.org/10.3138/jammi-2022-0008
11. Lubwama, M., Onyuka, J., Ayazika, K. T., Ssetaba, L. J., Siboko, J., Daniel, O., & Mushi, M. F. (2021). Knowledge, attitudes, and perceptions about antibiotic use and antimicrobial resistance among final-year undergraduate medical and pharmacy students at three universities in East Africa. PLOS ONE, 16(5), e0251301. https://doi.org/10.1371/journal.pone.0251301
12. Marzan, M., Islam, D. Z., Lugova, H., Krishnapillai, A., Haque, M., & Islam, S. (2021). Knowledge, attitudes, and practices of antimicrobial uses and resistance among public university students in Bangladesh. Infection and Drug Resistance, Volume 14, 519–533. <https://doi.org/10.2147/idr.s289964>
13. Olatunde, S. K., & Owolabi, J. B. (2022). Knowledge, attitudes, and practices of antibiotic use and antimicrobial resistance among medical students in a private university in Dominica, West Indies. Advances in Microbiology, 12(9), 511–524. https://doi.org/10.4236/aim.2022.129035
14. Parmanik, A., Das, S., Kar, B., Bose, A., Dwivedi, G. R., & Pandey, M. M. (2022). Current treatment strategies against multidrug-resistant bacteria: A review. Current Microbiology, 79(388). https://doi.org/10.1007/s00284-022-03061-7
15. Precha, N., Sukmai, S., Hengbaru, M., Chekoh, M., Laohaprapanon, S., Makkaew, P., & Dom, N. C. (2022). Knowledge, attitudes, and practices regarding antibiotic use and resistance among health science and non-health science university students in Thailand. Research Square. https://doi.org/10.21203/rs.3.rs-2082851/v1
16. Prestinaci, F., Pezzotti, P., & Pantosti, A. (2015). Antimicrobial resistance: A global multifaceted phenomenon. *Pathogens and Global Health*, 109(7), 309–318. https://doi.org/10.1179/2047773215Y.0000000030
17. Sakr, S., Ghaddar, A., Hamam, B., & Sheet, I. (2020). Antibiotic use and resistance: An unprecedented assessment of university students’ knowledge, attitude, and practices (KAP) in Lebanon. BMC Public Health, 20, 535. https://doi.org/10.1186/s12889-020-08676-8
18. Shah, P., Shrestha, R., Mao, Z., Chen, Y., Koju, P., Liu, X., & Li, H. (2019). Knowledge, attitude, and practice associated with antibiotic use among university students: A survey in Nepal. International Journal of Environmental Research and Public Health, 16(20), 3996. https://doi.org/10.3390/ijerph16203996
19. Aziz, M. M., Haider, F., Rasool, M. F., Hashmi, F. K., Bahsir, S., Li, P., Zhao, M., Alshammary, T. M., & Fang, Y. (2021). Dispensing of Non-Prescribed Antibiotics from Community Pharmacies of Pakistan: A Cross-Sectional Survey of Pharmacy Staff’s Opinion. Antibiotics, 10(5), 482. <https://doi.org/10.3390/antibiotics10050482>
20. Shahnaz, S., Khan, M. A., Nisa, Z. U., Alam, S., Ali, S. I., Khatian, N., & Fatima, R. (2020). Knowledge, attitude, and practice (KAP) of pharmacy students regarding the use of antibiotics in Karachi. Archives of Pharmacy Practice, 11(4), 135–140. https://doi.org/10.22259/2638-4787.0401001
21. Shallcross, L. J., Davies, D. S., & Hayward, A. C. (2018). Antibiotic use and resistance in university students in the United Kingdom: A survey study. *Public Health Reviews, 39*(6), 112–125. <https://doi.org/10.1093/jac/dkx048>
22. Shatla, M., Althobaiti, F. S., & Almqaiti, A. (2022). Public knowledge, attitudes, and practices towards antibiotic use and antimicrobial resistance in the Western Region of Saudi Arabia. Cureus, 14(11), e31857. https://doi.org/10.7759/cureus.31857
23. Sunusi, L. S., Awad, M. M., Hassan, N. M., & Isa, C. A. (2019). Assessment of knowledge and attitude toward antibiotic use and resistance among students of International University of Africa, Medical Complex, Sudan. Global Drugs and Therapeutics, 4(1), 1–6. <https://doi.org/10.15761/GDT.1000171>
24. Tembo, N., Mudenda, S., Banda, M., Chileshe, M., & Matafwali, S. (2022). Knowledge, attitudes, and practices on antimicrobial resistance among pharmacy personnel and nurses at a tertiary hospital in Ndola, Zambia: Implications for antimicrobial stewardship programs. JAC Antimicrobial Resistance, 4(5), dlac107. https://doi.org/10.1093/jacamr/dlac107
25. Zhang, Q.-Q., Ying, G.-G., Pan, C.-G., Liu, Y.-S., & Zhao, J.-L. (2015). Comprehensive evaluation of antibiotics in the environment: Occurrence, biodegradation, and ecological risks. *Environmental International*, 92–93, 161–173. https://doi.org/10.1016/j.envint.2016.03.015