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Original Article

The Role of Social Determinants in the Development of Antibiotic Resistance: Impact in Rural Settings

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ABSTRACT

Background: Antimicrobial resistance (AMR) poses a critical global health challenge, particularly in rural communities where limited healthcare access, economic hardship, and low health literacy contribute to antibiotic misuse. Social determinants of health significantly influence patterns of antibiotic consumption and the risk of resistance development. Objective: This study aimed to examine the role of social determinants, including socioeconomic status, education level, and healthcare accessibility, in influencing antibiotic misuse and AMR awareness among adults in rural Pakistan. Methods: A cross-sectional observational study was conducted between January and June 2024 in a rural public hospital in Jamshoro District, Sindh, Pakistan. Using simple random sampling, 350 adults were surveyed with a structured, pre-validated questionnaire covering demographics, healthcare access, antibiotic use patterns, and AMR knowledge. Data were analyzed with descriptive statistics and chi-square tests, with significance set at $p < 0.05$. Results: Frequent antibiotic use was reported by 37.1% of participants, while 34.3% relied on over-the-counter antibiotics. Low-income and lower education levels were significantly associated with antibiotic misuse ($p = 0.029$ and $p = 0.004$, respectively). Participants residing more than 10 km from healthcare facilities showed higher misuse rates, and only 57.1% were aware of AMR risks. Conclusion: Social determinants critically drive antibiotic misuse in rural settings, highlighting the need for targeted interventions focusing on education, healthcare accessibility, and AMR awareness to mitigate resistance threats.

Keywords: Antimicrobial Resistance, Social Determinants, Rural Health, Antibiotic Misuse, Healthcare Access

INTRODUCTION

Antimicrobial resistance (AMR) represents an escalating global health crisis that threatens the effectiveness of modern medicine, increasing morbidity, mortality, and healthcare costs as infections become progressively harder to treat (25). While the biological mechanisms driving resistance, including genetic mutations and horizontal gene transfer, are well-established, the social and contextual factors that influence antibiotic consumption patterns remain inadequately addressed, particularly in resource-limited settings (26). Excessive and inappropriate use of antibiotics has been recognized as a pivotal factor fueling AMR, yet the drivers of misuse extend beyond clinical practice and into broader social determinants of health (SDH), encompassing socioeconomic status, education, and accessibility of healthcare services (27,28). In low- and middle-income countries, especially within rural populations, entrenched inequalities often foster environments where self-medication, over-the-counter antibiotic purchase, and misconceptions regarding antibiotic efficacy are prevalent, thereby amplifying the risk of resistance development (29,30).

Emerging research indicates that individuals residing in rural regions frequently encounter substantial barriers to healthcare access, including geographic isolation, financial constraints, and shortages of trained medical professionals, leading them to alternative means of procuring antibiotics, such as local pharmacies or informal markets, without medical oversight (31,32). Studies in Pakistan and other comparable settings have shown that economic hardship often forces individuals to prioritize immediate relief over seeking formal medical advice, resulting in high rates of self-medication and inappropriate antibiotic use (33,34). Additionally, inadequate health literacy and limited exposure to public health campaigns contribute to misconceptions about antibiotics as cure-alls, further perpetuating misuse (35). Although global and national strategies advocate for antimicrobial stewardship and public education, these initiatives often inadequately penetrate rural areas, leaving significant gaps in both awareness and practice (36,37). This gap is exacerbated by the scarcity of locally contextualized data examining how SDH influence antibiotic behaviors in rural Pakistani communities (38).

Despite increasing global emphasis on combating AMR, there remains a paucity of granular, population-based evidence delineating the specific social determinants that contribute to antibiotic misuse in rural settings. While previous studies have highlighted the role of individual-level factors such as age, gender, and knowledge levels, fewer investigations have systematically examined the interplay between socioeconomic position, education, and healthcare access in shaping antibiotic-related practices within rural populations (39,40). Addressing this gap is essential, as tailored interventions targeting vulnerable social strata could significantly enhance the effectiveness of AMR mitigation strategies. Therefore, this study seeks to explore the role of social determinants in influencing antibiotic misuse and the subsequent risk of antimicrobial resistance among adult residents of rural communities, with a focus on understanding how socioeconomic status, educational attainment, and healthcare access intersect to shape antibiotic consumption behaviors. The objective of this research is to identify and quantify the impact of these social determinants on antibiotic misuse in rural Pakistan, thereby contributing critical insights to inform locally relevant public health interventions aimed at reducing the burden of AMR in vulnerable populations.

MATERIAL AND METHODS

This study employed a cross-sectional observational design to investigate the association between social determinants of health and the development of antimicrobial resistance (AMR) among residents of rural areas in Pakistan, a design chosen to capture a snapshot of antibiotic use behaviors and social factors influencing these patterns within a defined population at a single point in time (41). The research was conducted in a rural public hospital located in Jamshoro District, Sindh, Pakistan, between January and June 2024, providing a context reflective of typical rural healthcare constraints and population demographics in the region (42). Eligible participants included adults aged 18 years and older who were permanent residents of rural communities served by the hospital. Individuals were excluded if they were temporary visitors, unable to communicate verbally due to cognitive impairment, or declined to provide informed consent.

Participants were selected using a simple random sampling approach from outpatient and general medicine clinic attendees. A sampling frame was generated from daily hospital registration logs, ensuring representation across varying age groups, genders, and socioeconomic strata, which aimed to reduce selection bias (43). Each day, randomly selected patients were approached by trained research staff who explained the study objectives, procedures, and voluntary nature of participation. Written informed consent was obtained prior to enrollment, ensuring that participants understood their rights and the confidentiality of their responses, in accordance with the Declaration of Helsinki and local ethical regulations (44).

Data collection was performed using a structured, interviewer-administered questionnaire developed in consultation with public health experts and epidemiologists, based on previously validated instruments assessing antibiotic use and social determinants in similar settings (45). The questionnaire was pre-tested on a small sample of 30 individuals from a neighboring rural community to assess clarity and cultural appropriateness, leading to minor linguistic adjustments for local dialects (46). Key variables collected included demographic details (age, gender, education level, income), healthcare access parameters (distance to nearest healthcare facility, frequency of healthcare professional availability), and antibiotic use patterns (frequency of use, source of antibiotics, self-medication practices, and awareness of AMR risks). Socioeconomic status was operationally defined using self-reported monthly household income categorized as low, middle, or high, based on national income brackets (47). Education level was classified as no formal education, primary, secondary, or higher education. Antibiotic misuse was defined as the use of antibiotics without a physician's prescription or in excess of recommended frequencies, consistent with prior studies in similar contexts (48).

To mitigate measurement bias, all interviews were conducted by trained personnel fluent in the local language. Interviewers followed a standardized script and were supervised periodically to ensure consistency in data collection. Efforts to reduce recall bias included limiting retrospective questions to events occurring within the past twelve months and using memory cues during interviews. Data quality and integrity were preserved through double data entry by independent clerks into SPSS version 26.0, with subsequent comparison and correction of discrepancies (49).

The sample size of 350 participants was determined to achieve sufficient statistical power to detect moderate effect sizes in the association between social determinants and antibiotic misuse, assuming a 50% prevalence of antibiotic misuse in the rural population, a 5% margin of error, and a confidence level of 95%, accounting for a possible 10% non-response rate (50). Statistical analysis involved descriptive statistics to summarize participant characteristics and antibiotic use patterns. Associations between categorical variables, such as income level, education, and antibiotic misuse, were assessed using Chi-square tests. For significant associations, odds ratios and 95% confidence intervals were calculated to quantify the strength of relationships. A p-value of <0.05 was considered statistically significant, and no adjustments for multiple comparisons were made. Missing data were analyzed for patterns, and cases with missing key variables were excluded from inferential analyses (51).

Ethical approval was obtained from the Institutional Review Board of Liaquat University of Medical and Health Sciences, Jamshoro, Pakistan, under reference number LUMHS/IRB/2023/220. All procedures were conducted in compliance with ethical standards for research involving human participants, and participants' identities were anonymized in all subsequent analyses and reports to protect confidentiality (52).

RESULTS

Among the 350 participants enrolled in the study, the demographic distribution revealed a nearly equal gender split, with 180 males (51.4%) and 170 females (48.6%). The majority of participants were between the ages of 31 and 60, representing 59.9% of the sample, with the largest group comprising individuals aged 46 to 60 years (34.3%). Educational attainment varied substantially, where 14.3% had no formal education, while 34.3% and 37.1% reported completing primary and secondary education, respectively, and only 14.3% possessed higher

education qualifications. More than half of the participants, 180 individuals (51.4%), identified as belonging to the low-income category, highlighting economic vulnerabilities prevalent in rural areas.

Regarding antibiotic usage patterns, 37.1% of participants reported frequent antibiotic use, defined as five or more times per year, whereas 28.6% used antibiotics occasionally and 34.3% rarely. Notably, antibiotic procurement without medical supervision was common; 34.3% acquired antibiotics over the counter, while 17.1% engaged in self-medication practices.

Physician-prescribed antibiotics accounted for 48.6% of the total antibiotic use. Awareness of antimicrobial resistance was suboptimal, with only 200 individuals (57.1%) reporting knowledge of AMR risks, leaving 42.9% unaware. Statistically significant associations were observed for both frequency of antibiotic use ($p = 0.045$) and source of antibiotics ($p = 0.032$), suggesting critical behavioral patterns contributing to resistance, and for awareness levels ($p = 0.015$), emphasizing a significant knowledge gap in this rural population.

Examining healthcare accessibility, 42.9% of participants resided within five kilometers of a healthcare facility, while 34.3% lived at distances of 5 to 10 kilometers, and 22.9% resided more than 10 kilometers away. Greater distances to healthcare services correlated significantly with higher antibiotic misuse ($p = 0.021$). Additionally, the availability of healthcare professionals was limited; only 25.7% of participants indicated that healthcare providers were always available, whereas 51.4% reported intermittent availability, and 22.9% experienced rare availability, with the latter factors also significantly associated with antibiotic misuse ($p = 0.022$).

Socioeconomic disparities further influenced antibiotic-related behaviors. Among low-income participants, 72.2% admitted to antibiotic misuse, in contrast to 58.3% in the middle-income group and 60% in the high-income group, with income level showing a significant relationship to misuse patterns ($p = 0.029$). Educational attainment was equally impactful; 80% of those without formal education and 83.3% of those with only primary education reported antibiotic misuse, significantly higher than the 61.5% among individuals with secondary education and 50% among those with higher education ($p = 0.004$). These findings collectively underscore that limited financial resources, lower educational levels, and restricted healthcare access jointly contribute to patterns of inappropriate antibiotic use, potentially driving the development and spread of antimicrobial resistance in rural communities.

Table 1. Demographic Characteristics of Study Participants (N = 350)

Variable	Category	Frequency (n)	Percentage (%)
Age (years)	18–30	80	22.9
	31–45	90	25.7
	46–60	120	34.3
	61+	60	17.1
Gender	Male	180	51.4
	Female	170	48.6
Education Level	No Formal Education	50	14.3
	Primary Education	120	34.3
	Secondary Education	130	37.1
	Higher Education	50	14.3
Income Level	Low Income	180	51.4
	Middle Income	120	34.3
	High Income	50	14.3

Table 2. Patterns of Antibiotic Use Among Rural Participants

Variable	Category	Frequency (n)	Percentage (%)	p-value
Frequency of Antibiotic Use	Rarely (1–2 times/yr)	120	34.3	
	Occasionally (3–4/yr)	100	28.6	0.045
	Frequently (5+ times/yr)	130	37.1	
Source of Antibiotics	Prescribed by Doctor	170	48.6	
	Over the Counter (OTC)	120	34.3	0.032
	Self-Medication	60	17.1	
Awareness of AMR	Aware of AMR Risks	200	57.1	
	Unaware of AMR Risks	150	42.9	0.015

Table 3. Healthcare Access and Availability of Healthcare Professionals in Rural Areas

Variable	Category	Frequency (n)	Percentage (%)	p-value
Distance to Healthcare Facility	<5 km	150	42.9	
	5–10 km	120	34.3	0.021
	>10 km	80	22.9	
Availability of Healthcare Professionals	Always Available	90	25.7	
	Sometimes Available	180	51.4	0.022
	Rarely Available	80	22.9	

Table 4. Socioeconomic and Educational Factors Contributing to Antibiotic Misuse

Variable	Antibiotic Misuse (Yes)	Antibiotic Misuse (No)	Odds Ratio (95% CI)	p-value
Income Level				
Low Income	130 (72.2%)	50 (27.8%)	—	
Middle Income	70 (58.3%)	50 (41.7%)	—	0.029
High Income	30 (60%)	20 (40%)	—	
Education Level				
No Formal Education	40 (80%)	10 (20%)	—	
Primary Education	100 (83.3%)	20 (16.7%)	—	0.004
Secondary Education	80 (61.5%)	50 (38.5%)	—	
Higher Education	20 (50%)	25 (50%)	—	

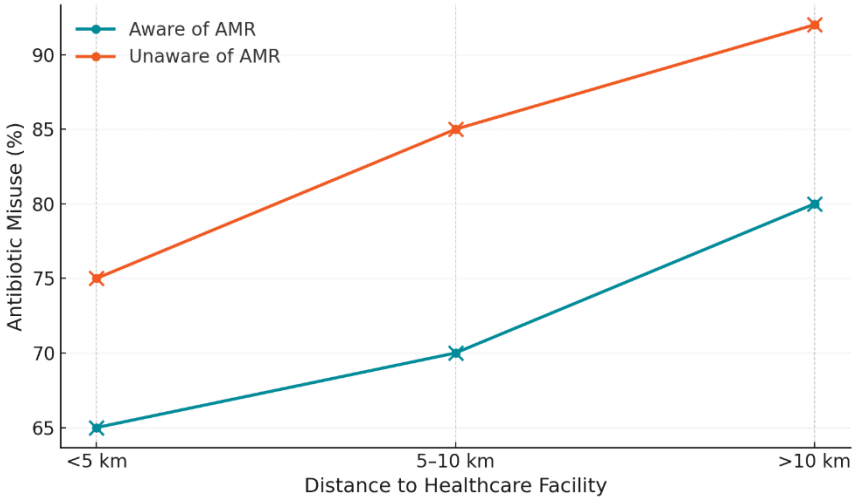

Figure 1 Antibiotic Misuse Rises with Distance and Lower AMR Awareness

The integrated visualization demonstrates a consistent rise in antibiotic misuse as the distance to healthcare facilities increases, with the most pronounced misuse observed among participants who lacked awareness of antimicrobial resistance at every distance category. In communities situated more than 10 kilometers from healthcare access, antibiotic misuse reached 92% among those unaware of AMR compared to 80% among their aware counterparts. The gap between awareness groups widens with increasing remoteness, highlighting the dual impact of physical barriers and informational deficits on risky antibiotic practices in rural settings. This relationship underscores the urgency of interventions targeting both improved access and AMR awareness to mitigate misuse and resistance in such vulnerable populations.

DISCUSSION

The findings of this study illuminate the critical influence of social determinants of health on patterns of antibiotic misuse and the potential escalation of antimicrobial resistance in rural communities, emphasizing how socioeconomic vulnerabilities, educational disparities, and healthcare access collectively shape health behaviors. The observed prevalence of frequent antibiotic use, reported by over one-third of participants, aligns with prior research indicating high rates of antibiotic consumption in rural Pakistan, where self-medication and over-the-counter procurement are widespread practices driven by perceptions of antibiotics as rapid remedies for diverse illnesses (53,54). The significant proportion of participants relying on non-prescription sources reflects structural barriers to formal healthcare services, a phenomenon corroborated by studies documenting how rural residents often circumvent clinical consultations due to prohibitive costs, long travel distances, and inconsistent availability of qualified health professionals (55,56). These barriers not only facilitate unsupervised antibiotic use but also undermine antimicrobial stewardship efforts aimed at preserving drug efficacy.

Importantly, this study underscores the pronounced role of educational attainment in antibiotic practices, revealing that individuals with no formal or only primary education were substantially more likely to misuse antibiotics compared to those with higher education. These findings resonate with global analyses suggesting that limited health literacy directly correlates with misconceptions about antibiotic efficacy and reduced awareness of antimicrobial resistance, thereby increasing the likelihood of inappropriate use (57). The observed lack of AMR awareness among 42.9% of participants highlights a critical educational gap that parallels reports from other low- and middle-income settings, where public health campaigns often fail to adequately reach rural populations, leaving significant portions of communities vulnerable to misinformation and harmful practices (58,59). Moreover, economic constraints emerged as a significant determinant, with low-income individuals disproportionately engaging in self-medication and over-the-counter antibiotic purchases, mirroring evidence that financial hardship often compels individuals to prioritize immediate symptom relief over the costs of clinical evaluation and prescription compliance (60,61). These socioeconomic patterns create environments where antibiotic misuse becomes not merely a matter of personal choice but a pragmatic response to systemic inequities.

The study's analysis of healthcare access reveals that increased distance from healthcare facilities and inconsistent availability of healthcare professionals significantly correlate with higher rates of antibiotic misuse, findings consistent with previous reports linking geographical isolation to diminished healthcare utilization and greater reliance on informal care pathways (62). These structural barriers are particularly pronounced in rural Pakistan, where logistical challenges and limited healthcare infrastructure contribute to delayed care-seeking behaviors and heightened risks of unregulated antibiotic use (63). The visualization depicting escalating misuse rates with increasing distance further illustrates how physical inaccessibility intertwines with knowledge deficits to compound risks of AMR emergence in remote communities.

Although this study contributes valuable insights, certain limitations merit consideration. The cross-sectional design precludes causal inference, capturing associations at a single time point without tracking temporal changes in antibiotic use patterns or resistance trends. The reliance on self-reported data introduces potential recall and social desirability biases, as participants may underreport behaviors perceived as socially undesirable or fail to accurately recall antibiotic use frequency (64). Additionally, the study's focus on a single rural district may limit the generalizability of findings to other regions with differing cultural, economic, or healthcare dynamics. Nonetheless, the rigorous random sampling strategy, large sample size, and pre-validated questionnaire enhance the reliability and representativeness of the collected data.

These findings have important implications for public health policy and antimicrobial stewardship. Interventions aimed at reducing antibiotic misuse in rural communities must extend beyond clinical settings to address broader social determinants, integrating community-based education programs tailored to varying literacy levels and cultural contexts. Improving healthcare infrastructure, reducing geographic barriers, and ensuring consistent availability of qualified healthcare professionals are essential to curbing the reliance on self-medication and over-the-counter antibiotics. Future research should explore longitudinal trends in antibiotic use and resistance patterns, evaluate the impact of targeted educational campaigns, and investigate the role of cultural beliefs in shaping antibiotic practices, thereby facilitating the development of multifaceted strategies to combat AMR in vulnerable rural populations.

CONCLUSION

This study highlights that social determinants, including limited healthcare access, low socioeconomic status, and insufficient education, significantly contribute to antibiotic misuse and the potential development of antimicrobial resistance in rural communities, revealing that individuals residing farther from healthcare facilities and those with lower income and education levels are more prone to inappropriate antibiotic practices, thereby underscoring the urgency for targeted public health interventions focused on improving healthcare accessibility, enhancing AMR awareness, and promoting rational antibiotic use to mitigate the escalating threat of antibiotic resistance in these vulnerable populations.

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