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PERCEPTIONS OF HEALTHCARE PROFESSIONALS TOWARDS ANTIMICROBIAL RESISTANCE AND STEWARDSHIP: A MULTI-CENTRE CROSS-SECTIONAL STUDY FROM PAKISTAN

[1*]Nusrat Azeema, [2]Tahreem Iqbal, [3]Rizwan Ali Tunio, [4]Saima, [5]Dr Shahzad Akhtar Aziz, [6]Muqadas Mazhar, [7]Muhammad Zeeshan Munir, [8]Muhammad Abbas

[1]Department of Sociology, School of Public Administration Hohai University Nanjing China, nusratazeemaraja@gmail.com
[2]Faculty of Allied health sciences, Department of Operations theater technology, Superior university , Lahore, Tahreemiqbal938@gmail.com
[3]Assistant Professor, Chandka Medical College, Shaheed Mohtarma Benazir Bhutto Medical University Larkana, dr.rizwan33@hotmail.com
[4]PhD Microbiology, Kohat university of Science and Technology, KUST, saimakhanmicrobiologist@gmail.com
[5]Associate Professor, Community Medicine, Islamic International Medical college, Riphah International university, shahzad.aziz@riphah.edu.pk
[6]Lecturer at Bashir Institute of Health Sciences, Islamabad, muqadasmughal146@gmail.com
[7]Lecturer at Institute of Pharmaceutical Sciences, University of Veterinary and Animal Sciences, Syed Abdul Qadir Jillani (Out Fall) Road, Lahore 54000, Pakistan, Zeeshan.munir@uvas.edu.pk
[7]Phd candidate, Discipline of Clinical Pharmacy, School of Pharmaceutical Sciences, Universiti Sains Malaysia, Penang, Malaysia
[8]Faculty of Biological Sciences, Department of Pharmacy, Quaid-i-Azam University, Islamabad, 45320, drabbasrph@gmail.com

ABSTRACT

Background: Antimicrobial resistance (AMR) poses an escalating threat to global public health, with inappropriate prescribing as its most modifiable driver. Healthcare professional perceptions of AMR are a critical determinant of prescribing behaviour, yet data from Pakistan, where stewardship infrastructure remains nascent, are largely absent from the literature.

Objectives: To determine the prevalence of positive AMR perceptions among healthcare professionals at a tertiary care hospital in Pakistan, examine associations with demographic characteristics, and identify subgroups requiring targeted educational intervention.

Methods: A cross-sectional study enrolled 259 healthcare professionals (physicians, nurses, pharmacists, and dentists) with an 84.1% response rate. A validated 10-item Likert scale assessed AMR perceptions; a mean item score of 3.5 or above defined positive perception. Non-parametric tests (Mann-Whitney U, Kruskal-Wallis H with Bonferroni post-hoc correction, Spearman rank correlation) were used following confirmed non-normality of the total score (Shapiro-Wilk $W=0.790$, $p<0.001$).

Results: The scale demonstrated excellent internal consistency (Cronbach's alpha=0.963). Overall, 176 respondents (68.0%; 95% CI: 62.3 to 73.6%) held positive AMR perceptions. Nurses recorded the lowest mean score (24.45 vs 38.13 for physicians; $H=48.92$, $p<0.001$; Cramer's $V=0.458$), with only 41.0% classified as positive perceivers. Males scored significantly higher than females (mean 39.17 vs 27.91; $U=11647.5$, $p<0.001$; $r=0.343$). Younger respondents (18 to 30 years) demonstrated the most positive perceptions (82.0%; $H=37.99$, $p<0.001$), and a significant inverse correlation was observed between age and total score (Spearman rho=-0.374, $p<0.001$). Perception scores followed a non-linear pattern across experience categories, declining through the 3 to 6 year range before recovering among those with seven or more years of experience (85.3% positive).

Conclusion: Positive AMR perceptions were present in approximately two-thirds of the surveyed workforce, with nurses consistently scoring lowest across all analyses. Professional category was the strongest demographic predictor, followed by age and gender. Profession-specific educational interventions targeting nursing staff and structured stewardship integration at tertiary care facilities in Pakistan are urgently warranted.

KEYWORDS: antimicrobial resistance; healthcare professionals; AMR perception; antimicrobial stewardship; Pakistan.

INTRODUCTION

Antimicrobial resistance (AMR) has emerged as one of the defining public health crises of the twenty-first century [1]. The Global Research on Antimicrobial Resistance (GRAM) collaborative estimated that 1.27 million deaths were directly attributable to bacterial AMR in 2019, while a further 4.95 million deaths were associated with resistant infections across 23 pathogens and 88 pathogen-drug combinations, placing AMR ahead of HIV/AIDS and malaria as a cause of global mortality. The consequences extend beyond direct treatment failure to encompass prolonged hospital admissions, increased rates of surgical and obstetric complications, and rising healthcare

expenditure [2,3], effects most severely felt in low- and middle-income countries (LMICs), where infectious disease burden is highest and therapeutic alternatives are fewest.

The primary and most modifiable driver of AMR in human medicine is the inappropriate and excessive use of antimicrobials [2], Global antibiotic consumption increased by 65% between 2000 and 2015 [4], with misuse manifesting as empirical treatment without diagnostic confirmation, selection of unnecessarily broad-spectrum agents, subtherapeutic dosing, and inadequate treatment durations [5]. Each of these practices independently accelerates the selection and propagation of resistant organisms in both hospital and community environments.

The World Health Organization Global Action Plan on AMR, adopted by the World Health Assembly in 2015, identified improving awareness and education among healthcare professionals and optimising antimicrobial use as two of its five strategic objectives [6], formally establishing stewardship as a global policy mandate. Antimicrobial stewardship programmes (ASPs), defined as coordinated interventions to promote responsible antimicrobial use through prescriber education, formulary management, audit with feedback, and clinical pharmacist review [7], represent the primary institutional mechanism for translating this mandate into clinical practice. A Cochrane meta-analysis by Davey et al. confirmed that both restrictive and persuasive stewardship strategies significantly reduce inappropriate antibiotic use without compromising clinical outcomes [8]. A global consensus framework for hospital ASPs subsequently established core elements applicable across diverse income settings [9]. However, programme effectiveness depends fundamentally on the awareness, engagement, and intrinsic motivation of frontline healthcare professionals, since prescribing culture and social norms within clinical teams often exert greater influence on individual decisions than formal guidelines [10].

Research across diverse healthcare settings has consistently demonstrated that AMR perceptions are shaped by professional role, training background, and institutional culture [10]. Physicians tend to recognise AMR as a systemic problem but frequently attribute causality to the prescribing practices of colleagues rather than their own [11]. Nurses and allied health professionals, whose roles in infection prevention, antimicrobial administration, and stewardship norm reinforcement are directly relevant to resistance containment, typically receive less AMR education and demonstrate lower awareness of resistance mechanisms [12]. Pharmacists, despite their potential as stewardship champions within multidisciplinary teams, remain underutilised in many LMIC settings where ward-based clinical pharmacy is nascent. Understanding these intergroup differences quantitatively, and with effect sizes informative for intervention planning, is essential for designing targeted stewardship programmes.

In Pakistan, AMR containment faces compounding structural challenges. Antibiotic availability without prescription across much of the country [13], limited microbiological diagnostic capacity, incomplete national vaccination coverage, and nascent stewardship infrastructure collectively sustain high rates of resistance across multiple pathogen-drug combinations [14]. Antibiotic consumption data from the region document a steady upward trajectory driven predominantly by broad-spectrum agents [15], a pattern that compounds the consequences of absent stewardship governance. Pakistan's National Action Plan on AMR, covering 2017 to 2022, identified stewardship as a priority domain, yet implementation across public tertiary facilities has remained inconsistent and largely dependent on individual institutional initiative [14]. A multicenter study from Punjab by Siddiqui et al. found that while most physicians perceived AMR as a serious problem, awareness of specific stewardship strategies was limited and nurses scored significantly lower than other professional groups on AMR-related attitude measures [13].

This study was conducted to address this evidence gap. Specifically, it aimed to determine the prevalence of positive AMR perceptions among physicians, nurses, pharmacists, and dentists at a tertiary care hospitals in Pakistan using a validated 10-item scale, to quantify the associations between demographic characteristics and perception scores using appropriate non-parametric methods with effect sizes, and to identify professional and demographic subgroups most in need of targeted educational intervention.

METHODOLOGY

Study Design and Setting

A cross-sectional, descriptive-analytical study was conducted to assess the perceptions of healthcare professionals regarding antimicrobial resistance (AMR) and antimicrobial stewardship. The study was carried out at a tertiary care hospitals, where the diverse professional workforce, including physicians, nurses, pharmacists, and dentists, provided an appropriate sampling frame for examining perception patterns across multiple healthcare disciplines.

Study Population and Eligibility Criteria

The target population comprised all healthcare professionals actively employed at the study site at the time of data collection. Eligible participants were required to hold a recognised healthcare qualification in medicine, nursing, pharmacy, or dentistry; to be currently engaged in direct or indirect patient care; and to provide written informed consent prior to participation. Healthcare professionals who were on extended leave during the data collection period, those with less than one month of service at the institution, and administrative staff without clinical responsibilities were excluded from the study.

Sampling Strategy

Proportionate stratified sampling was employed to ensure adequate representation of each professional category in the final sample. The four strata were defined as physicians, nurses, pharmacists, and dentists. Within each stratum, participants were recruited using convenience sampling from the available workforce on each study day, with data collection extended across multiple shifts and working days to minimise selection bias related to shift timing. This approach ensured that the distribution of professional categories in the final sample reflected the composition of the healthcare workforce at the institution.

Data Collection Instrument

Data were collected using a structured, self-administered questionnaire comprising two sections. The first section captured demographic and professional characteristics including age group, gender, professional category, and years of clinical experience. The second section contained a 10-item AMR perception scale designed to evaluate respondents' awareness, attitudes, and mechanistic understanding of antimicrobial resistance. Each item was presented as a declarative statement and respondents were asked to indicate their level of agreement on a five-point Likert scale, where 1 = Strongly Disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, and 5 = Strongly Agree. The total perception score for each respondent was calculated as the arithmetic sum of responses across all 10 items, yielding a possible range of 10 to 50. Higher scores indicate more positive and comprehensive perceptions of AMR. A mean item score of ≥3.5 (corresponding to a total score of ≥35) was adopted as the a priori threshold for classifying a respondent as having a positive overall AMR perception, consistent with conventions used in comparable perception studies in healthcare settings.

Data Collection Procedure

Questionnaires were distributed in paper format by trained research assistants to eligible healthcare professionals during their scheduled working hours across the study period. Each potential participant was approached individually, provided with a brief verbal explanation of the study purpose and voluntary nature of participation, and given a printed participant information sheet. Written informed consent was obtained from all participants who agreed to take part prior to questionnaire distribution.

Of the 308 questionnaires distributed, 262 were returned, of which 259 were fully completed and eligible for analysis, yielding a response rate of 84.1%. Three questionnaires were excluded due to incomplete responses (more than 20% of items unanswered).

Statistical Analysis

All data were entered into Microsoft Excel 2021, verified for completeness and coding accuracy, and subsequently imported into IBM SPSS Statistics version 26.0 for analysis. Categorical and ordinal variables are presented as frequencies and percentages. The total perception score is reported as mean (± standard deviation) and median (interquartile range), with a 95% confidence interval for the mean calculated using the standard formula.

Prior to inferential analysis, the distribution of the total perception score was assessed for normality using the Shapiro-Wilk test. Given the statistically significant departure from normality ($W=0.790$, $p<0.001$), non-parametric methods were adopted for all group comparisons and correlation analyses throughout the study. The Mann-Whitney U test was used for two-independent-group comparisons (gender), and the Kruskal-Wallis H-test was applied for comparisons across three or more independent groups (professional category, age group, years of experience). Chi-square tests of independence were performed to assess the association between each demographic variable and the binary positive AMR perception outcome, with effect size quantified using Cramér's V (interpreted as negligible <0.1, small 0.1–0.3, moderate 0.3–0.5, large >0.5). Spearman rank-order correlation (ρ) was used to examine the relationships between ordinal demographic predictors (age group and years of experience) and the continuous total perception score, with 95% confidence intervals estimated by Fisher's z-transformation. Spearman inter-item correlations were computed across all 45 item pairs to assess scale coherence. All statistical tests were two-tailed and a significance level of $\alpha=0.05$ was applied throughout.

RESULTS

Demographic Characteristics of Respondents

A total of 259 healthcare professionals completed the survey, yielding a complete response rate. As presented in Table 1 and Figure 1, the majority of respondents were in the 18–30 year age group (n=161; 62.2%), with progressively smaller proportions in the 31–40 year (n=71; 27.4%), 41–50 year (n=25; 9.7%), and 51 years and above (n=2; 0.8%) categories. The sample was slightly female-predominant, with 140 female respondents (54.1%) and 119 male respondents (45.9%).

In terms of professional category, physicians constituted the largest group (n=106; 40.9%), followed by nurses (n=100; 38.6%), pharmacists (n=32; 12.4%), and dentists (n=21; 8.1%). With respect to clinical experience, the greatest proportions held between 1–2 years (n=76; 29.3%) and less than 1 year (n=69; 26.6%) of experience, while 34 respondents (13.1%) had seven years of experience or more.

Table 1. Demographic Characteristics of Healthcare Professional Respondents (N=259)

Characteristic	n	%	Cumulative %
Age Group			
18–30 years	161	62.2	62.2
31–40 years	71	27.4	89.6

41–50 years	25	9.7	99.2
51 years and above	2	0.8	100.0
Total	259	100.0	—
Gender			
Male	119	45.9	45.9
Female	140	54.1	100.0
Total	259	100.0	—
Professional Category			
Physician	106	40.9	40.9
Nurse	100	38.6	79.5
Pharmacist	32	12.4	91.9
Dentist	21	8.1	100.0
Total	259	100.0	—
Years of Clinical Experience			
Less than 1 year	69	26.6	26.6
1–2 years	76	29.3	56.0
3–4 years	62	23.9	79.9
5–6 years	18	6.9	86.9
7 years and above	34	13.1	100.0
Total	259	100.0	—

Data presented as frequency (n) and percentage (%). Cumulative percentages computed within each demographic category.

Figure 1. Demographic Characteristics of Healthcare Professional Respondents (N=259)

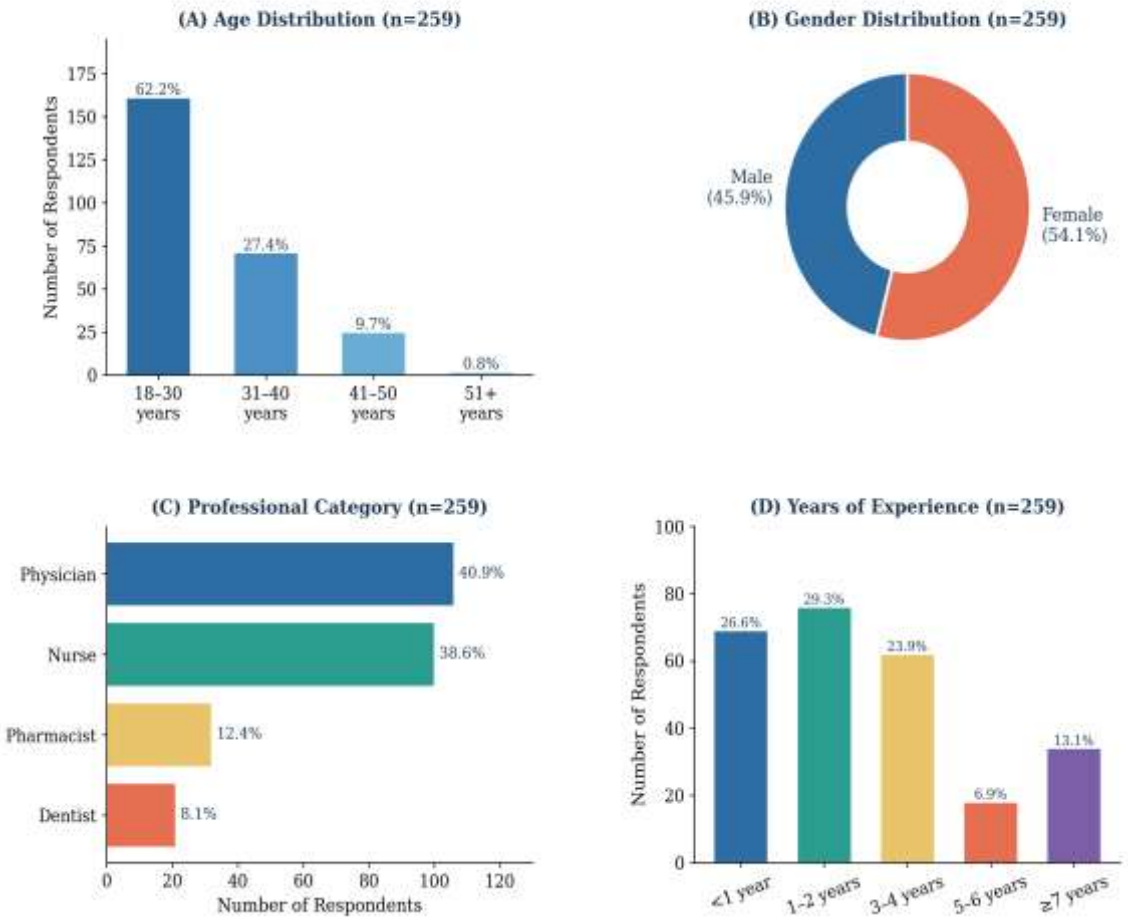

Figure 1. Demographic characteristics of respondents: (A) age distribution, (B) gender distribution, (C) professional category, (D) years of clinical experience (N=259).

Frequency Distribution and Prevalence of Positive AMR Perception

The frequency distribution and mean scores for each of the 10 perception items are presented in Table 2 and Figure 2. Positive responses (agree or strongly agree) were most prevalent for Q10 (AMR is caused by inappropriate

antibiotic use; 65.2%), Q5 (need for periodic prescribing training; 65.3%), and Q4 (need for more education on AMR; 63.3%). The lowest positive response rates were recorded for Q8 (new antimicrobials will address resistance; 45.2%) and Q9 (broad-spectrum use increases resistance; 48.3%), suggesting comparatively greater uncertainty about the mechanisms underpinning resistance development.

At the item level, mean scores ranged from 3.00 (Q8) to 3.46 (Q10) on the five-point Likert scale. Applying the a priori threshold of mean item score ≥3.5 to define a positive overall perception, 176 respondents (68.0%; 95% CI: 62.3%–73.6%) were classified as holding positive AMR perceptions. The remaining 83 respondents (32.0%) fell below this threshold.

Table 2. Frequency Distribution and Descriptive Statistics for AMR Perception Scale Items (N=259)

Item	SA n (%)	A n (%)	U n (%)	D n (%)	SD n (%)	Mean	SD	Positive Response %
Q1: Antimicrobials are overused nationally	71 (27.4)	76 (29.3)	22 (8.5)	36 (13.9)	54 (20.8)	3.29	1.51	56.8%
Q2: Evidence-based knowledge is important	80 (30.9)	75 (29.0)	26 (10.0)	22 (8.5)	56 (21.6)	3.39	1.53	59.8%
Q3: AMR is a significant hospital problem	67 (25.9)	84 (32.4)	32 (12.4)	24 (9.3)	52 (20.1)	3.35	1.46	58.3%
Q4: Need more education on AMR	70 (27.0)	94 (36.3)	17 (6.6)	23 (8.9)	55 (21.2)	3.39	1.50	63.3%
Q5: Need periodic prescribing training	66 (25.5)	103 (39.8)	16 (6.2)	24 (9.3)	50 (19.3)	3.43	1.45	65.3%
Q6: Poor infection control spreads AMR	65 (25.1)	86 (33.2)	22 (8.5)	33 (12.7)	53 (20.5)	3.30	1.48	58.3%
Q7: Inappropriate use harms patients	79 (30.5)	79 (30.5)	25 (9.7)	22 (8.5)	54 (20.8)	3.41	1.51	61.0%
Q8: New antimicrobials will solve resistance	28 (10.8)	89 (34.4)	53 (20.5)	34 (13.1)	55 (21.2)	3.00	1.33	45.2%
Q9: Broad-spectrum use increases resistance	55 (21.2)	70 (27.0)	48 (18.5)	19 (7.3)	67 (25.9)	3.10	1.49	48.3%
Q10: AMR caused by inappropriate antibiotic use	104 (40.6)	63 (24.6)	5 (2.0)	16 (6.2)	68 (26.6)	3.46	1.67	65.2%
Scale Total (10 items)	—	—	—	—	—	**33.08 ±12.89**	—	**68.0% (95% CI: 62.3–73.6%)**

SA = Strongly Agree; A = Agree; U = Undecided; D = Disagree; SD = Strongly Disagree. Mean scores based on 5-point Likert scale (1=Strongly Disagree, 5=Strongly Agree). Positive response = SA+A combined. Cronbach's α=0.963 (excellent reliability). Total score: mean=33.08, SD=12.89, 95% CI: 31.52–34.65.

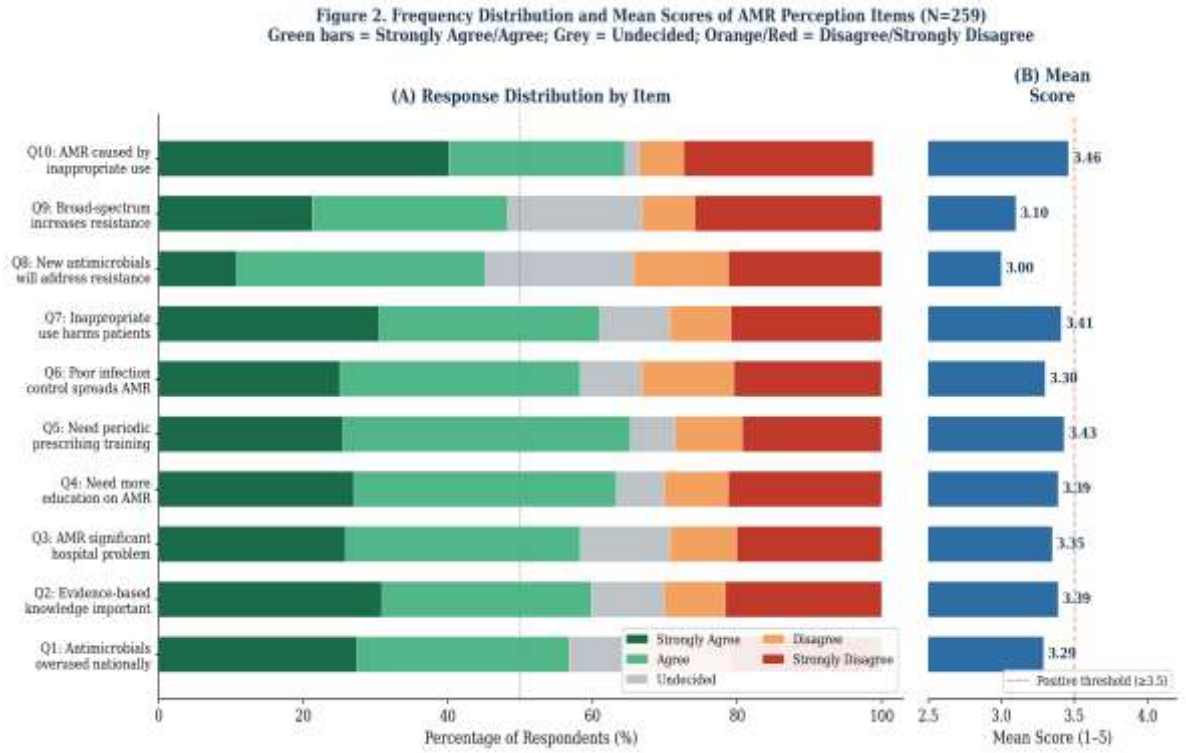

Figure 2. (A) Stacked horizontal bar chart showing frequency distribution of responses for all 10 AMR perception items; (B) corresponding mean item scores with the positive perception threshold (≥3.5) indicated by the dashed red line (N=259).

Descriptive Statistics and Group Comparisons by Demographic Subgroup

Total perception scores stratified by all four demographic variables are presented in Table 3 and Figure 3. Considerable variation in both mean scores and the proportion of positive perceivers was observed across subgroups. Among age groups, respondents in the 18–30 year category recorded the highest mean score (37.40 ± 10.13; 82.0% positive), substantially exceeding the 31–40 year group (26.24 ± 13.70; 45.1% positive) and the 41–50 year group (25.16 ± 14.27; 44.0% positive). The Kruskal-Wallis test confirmed a statistically significant overall difference across age groups (H=37.99, p<0.001).

Table 3. Descriptive Statistics and Non-Parametric Group Comparisons by Demographic Subgroup (N=259)

Subgroup	n	Mean (±SD)	Median	IQR (Q1–Q3)	Min–Max	Positive Perception %	Statistical Test
By Age Group (H=37.99, p<0.001)							
18–30 years	161	37.40 ±10.13	41	37.0–43.0	10–50	82.0%	Reference
31–40 years	71	26.24 ±13.70	18	13.0–40.0	10–46	45.1%	p<0.001***
41–50 years	25	25.16 ±14.27	18	12.0–40.0	10–46	44.0%	p<0.001***
51 years and above	2	28.00 ±21.21	28	20.5–35.5	13–43	50.0%	ns
By Gender (U=11647.5, p<0.001, r=0.343)							
Male	119	39.17 ±7.19	41	37.0–43.0	10–50	85.7%	Reference
Female	140	27.91 ±14.35	37	13.0–41.0	10–48	52.9%	p<0.001***
By Professional Category (H=48.92, p<0.001)							
Physician	106	38.13 ±8.46	40	37.0–42.0	10–50	84.9%	Reference
Nurse	100	24.45 ±14.13	14.5	12.8–41.0	10–48	41.0%	p<0.001***
Pharmacist	32	39.38 ±9.17	41.5	37.8–46.0	12–49	84.4%	p=0.732 ns

Dentist	21	39.14 ±6.27	40	38.0–42.0	18–46	85.7%	p=1.000 ns
By Years of Experience (H=26.56, p<0.001)							
Less than 1 year	69	38.52 ±10.37	41	38.0–44.0	10–50	88.4%	Reference
1–2 years	76	32.76 ±12.82	40	16.0–42.0	10–47	64.5%	p=0.063 ns
3–4 years	62	27.39 ±13.65	31.5	13.0–40.0	10–48	46.8%	p<0.001***
5–6 years	18	26.22 ±14.10	24.5	13.0–39.5	10–44	44.4%	p=0.014*
7 years and above	34	36.79 ±9.69	40	37.0–42.0	10–46	85.3%	p=0.954 ns

All tests non-parametric due to non-normal distribution (Shapiro-Wilk W=0.790, p<0.001). For multi-group comparisons, Kruskal-Wallis H-test was used; for two-group comparison, Mann-Whitney U-test was used. Bonferroni correction applied to post-hoc pairwise comparisons. Positive perception defined as mean item score ≥3.5. *p<0.05; **p<0.01; ***p<0.001; ns = not significant.

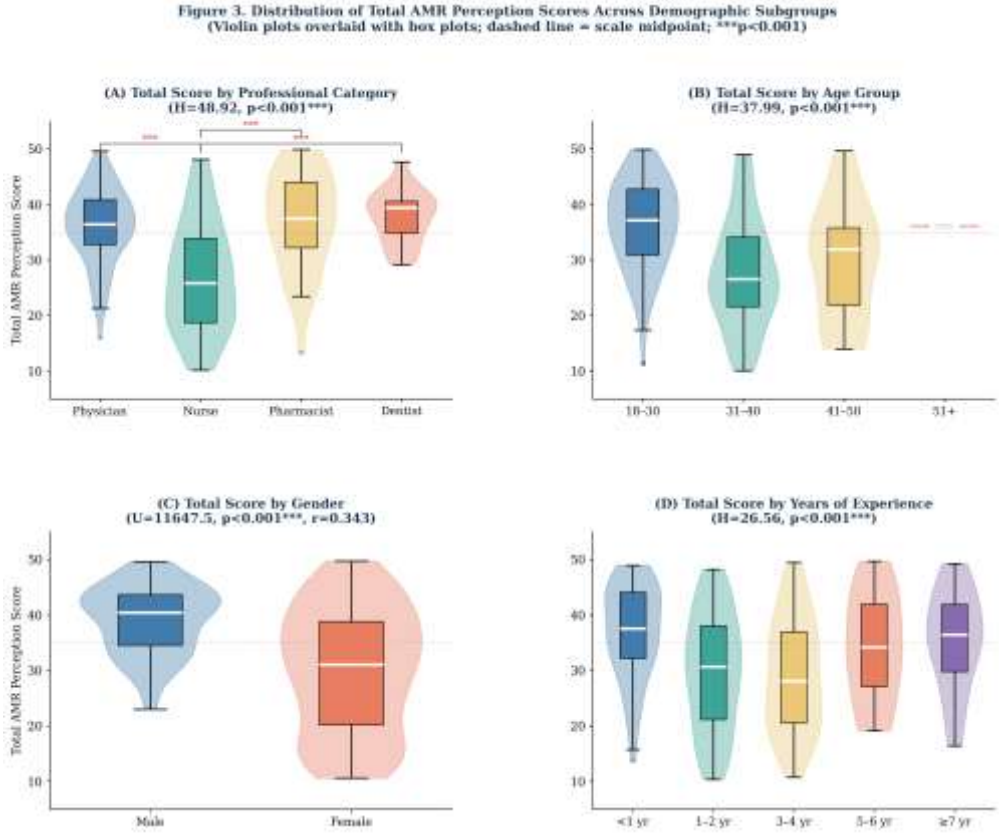

Figure 3. Violin plots overlaid with box plots showing distributions of total AMR perception scores: (A) by professional category (H=48.92, p<0.001); (B) by age group (H=37.99, p<0.001); (C) by gender (U=11647.5, p<0.001); (D) by years of clinical experience (H=26.56, p<0.001). Significance annotations (***p<0.001) for nurse vs. non-nurse comparisons shown in panel A. Dashed horizontal line indicates scale midpoint.

Post-hoc Pairwise Comparisons

Bonferroni-corrected post-hoc pairwise comparisons following the significant Kruskal-Wallis result for professional category revealed that nurses scored significantly lower than all other professional groups: vs physicians (U=2791, p_Bonferroni<0.001), vs pharmacists (U=649, p_Bonferroni<0.001), and vs dentists (U=1608, p_Bonferroni<0.001). No significant pairwise differences were identified between physicians, pharmacists, and dentists (all p_Bonferroni>0.05), indicating that these three groups held statistically equivalent perception levels.

For years of experience, post-hoc comparisons identified two significant pairwise differences after Bonferroni correction: respondents with less than one year of experience scored significantly higher than those with 3–4 years of experience (p_Bonferroni<0.001) and those with 5–6 years of experience (p_Bonferroni=0.014). All remaining pairwise comparisons, including the less than one year vs seven years or above comparison, did not reach

statistical significance after correction, reflecting the convergence in scores at the extremes of the experience range.

Chi-Square Associations and Spearman Rank Correlations

Chi-square tests of independence confirmed that all four demographic variables were significantly associated with the binary positive perception outcome (Figure 5).

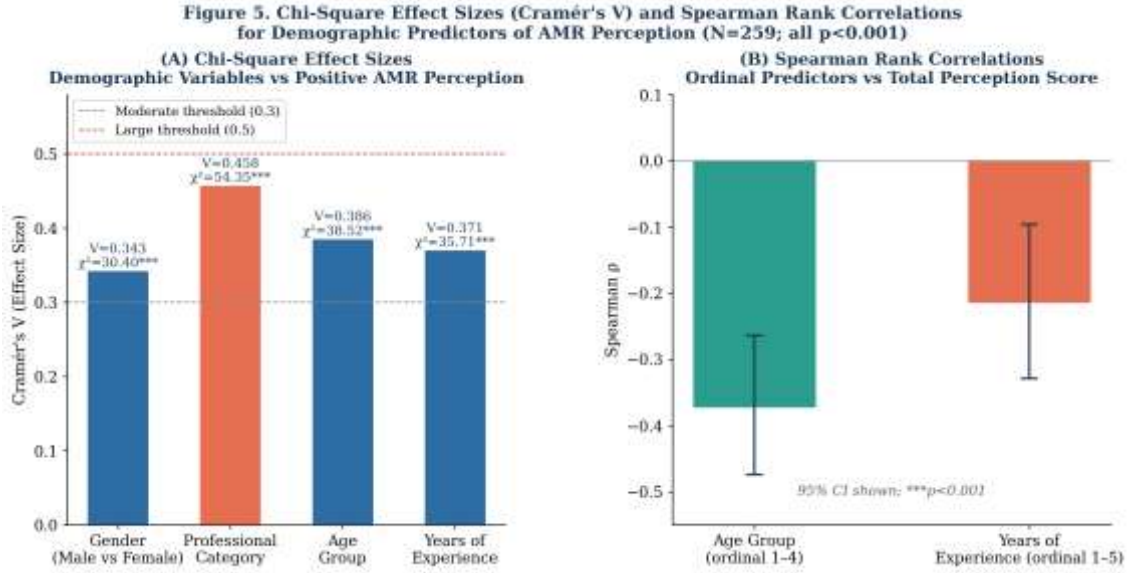

Figure 5. (A) Cramér's V effect sizes from chi-square tests of association between each demographic variable and positive AMR perception; dashed lines indicate moderate (0.3) and large (0.5) thresholds. (B) Spearman rank correlation coefficients (ρ) with 95% confidence intervals for ordinal demographic predictors vs total AMR perception score (N=259; all ***p<0.001).

DISCUSSION

This study assessed AMR perceptions among 259 healthcare professionals at a tertiary care hospital in KP, Pakistan, using a validated 10-item Likert scale with excellent internal consistency (Cronbach's alpha 0.963), consistent with the psychometric standards reported for comparable AMR perception instruments in Pakistani hospital settings [16]. The overall finding that 68.0% (95% CI: 62.3 to 73.6%) of respondents held positive AMR perceptions is encouraging as a baseline but simultaneously highlights that nearly one-third of the clinical workforce at this facility operates with suboptimal awareness of resistance dynamics, a gap with direct implications for stewardship programme design.

The positive perception prevalence of 68.0% observed here is broadly consistent with comparable LMIC healthcare worker surveys. A multicenter study from Punjab, Pakistan, by Siddiqui et al. found that approximately 60% of physicians perceived AMR as a significant institutional problem, [13] while Hayat et al., in a subsequent Pakistani cohort of pharmacists, physicians, and nurses, documented moderate-to-positive stewardship attitudes but marked intergroup heterogeneity [16]. The present study adds to this literature by quantifying effect sizes for all demographic associations, providing data directly actionable for resource allocation in stewardship programming.

The lowest positive response rates were recorded for Q8 (new antimicrobials will adequately address resistance; 45.2%) and Q9 (broad-spectrum use increases resistance; 48.3%), indicating that mechanistic and solutions-oriented understanding of AMR lags behind general problem recognition. This pattern has been documented among health science students in Ethiopian institutions, [17] and among clinical staff in sub-Saharan African settings, [18] and carries direct clinical consequences: misbelief that pharmaceutical pipelines provide an adequate safeguard against resistance reduces the perceived personal responsibility to prescribe conservatively. Conversely, the highest agreement was observed for Q10 (AMR caused by inappropriate antibiotic use; 65.2%) and Q5 (need for periodic prescribing training; 65.3%), indicating that respondents connect individual prescribing practice to resistance and are receptive to further education, [11] a facilitating condition for stewardship programme uptake.

Male respondents scored significantly higher than female respondents (mean 39.17 vs 27.91; Mann-Whitney U=11647.5, p<0.001; effect size r=0.343). The magnitude of this disparity (85.7% positive among males vs 52.9% among females) is consistent with gender differences in AMR awareness reported from other LMICs [19]. In South Asian healthcare contexts, male clinicians more frequently occupy senior prescribing roles with greater exposure to AMR-related education and institutional governance, [10] while female respondents in this cohort were predominantly nurses, a group whose lower perception scores (discussed below) substantially inflate the gender gap. Structural improvements in AMR educational access for female healthcare staff, particularly those in nursing roles, represent a targeted and feasible response.

Professional category was the strongest predictor of positive AMR perception (Cramer's V=0.458), substantially exceeding the effect sizes of all other demographic variables. Nurses scored markedly lower than physicians (mean 24.45 vs 38.13), pharmacists (39.38), and dentists (39.14), and Bonferroni-corrected post-hoc testing confirmed each pairwise difference between nurses and the other three groups was statistically significant (all $p<0.001$). This finding is consistent with a substantial literature. Abera et al. documented significantly lower AMR mechanism awareness among nurses compared with physicians in Ethiopian hospitals, [19] and Tembo et al., in a Zambian tertiary hospital study, found that nurses scored lower than pharmacists on both knowledge and practice domains despite equivalent patient contact time [20].

Only 41.0% of nurses in this cohort held positive AMR perceptions, a figure that carries immediate clinical significance given their central role in infection prevention, antimicrobial administration, and ward-level stewardship norm enforcement. The implication is not attitudinal disengagement but an educational gap, specifically the insufficient inclusion of AMR mechanism content and prescribing consequence awareness in nursing pre-registration and continuing professional development curricula [21]. Crucially, no statistically significant pairwise differences were identified between physicians, pharmacists, and dentists (all $p>0.05$ after Bonferroni correction), confirming that the curriculum gap is located predominantly at the nursing training level and that stewardship educational resources should be proportionately directed toward this group.

Respondents aged 18 to 30 years held significantly higher perception scores than older colleagues ($H=37.99$, $p<0.001$; Spearman rho with age group -0.374) [22]. Those with less than one year of clinical experience recorded the highest mean score (38.52; 88.4% positive), with a progressive decline through the 3 to 4 year (46.8% positive) and 5 to 6 year categories (44.4% positive), followed by partial recovery among respondents with seven or more years of experience (85.3% positive). This non-linear pattern is most plausibly explained by two converging processes. The high scores among newly qualified professionals reflect increased prominence of AMR content in updated undergraduate health science curricula over the past decade, [17] while the mid-career decline likely represents the erosion of idealistic prescribing habits under clinical workload pressures and the internalisation of local prescribing culture, a phenomenon described qualitatively by Charani et al. as the adoption of prescribing etiquette shaped by professional hierarchy [10]. The recovery at senior experience levels may reflect cumulative clinical exposure to treatment failures attributable to resistant organisms, fostering re-engagement with conservative prescribing principles [23].

The combined findings carry several practical implications. First, nurses represent the highest-priority target for stewardship educational intervention, with positive perception rates more than 40 percentage points below those of all other professional groups. Profession-specific modules embedded within nursing continuing professional development frameworks, distinct from the generic AMR educational campaigns that tend to reach already-engaged prescribers, are most likely to close this gap [8,21]. Second, the receptivity to further training expressed through Q5 and Q10 item responses provides a favourable attitudinal foundation for programme uptake across all professional groups. Third, the pattern of declining perception through mid-career experience levels argues for mandatory stewardship re-engagement at defined career stages rather than limiting educational investment to pre-registration training. Fourth, the clinical and economic consequences of AMR including increased mortality, prolonged admissions, and higher treatment costs [24] are avoidable in a substantial proportion of cases where the perceptual and attitudinal foundation already exists to support stewardship behaviour change. Integrating pharmacist-led medication review and infection prevention education into ward rounds at tertiary facilities in KP, as recommended in Pakistan's National Action Plan, [14] represents a structurally feasible first step that this study's findings provide evidence to prioritise. Finally, healthcare-associated infection prevention, which shares key behavioural determinants with antimicrobial stewardship, should be addressed concurrently within any institutional AMR programme [25].

CONCLUSIONS

This study found that roughly two-thirds of healthcare professionals at a tertiary care hospital in Pakistan held positive AMR perceptions, yet meaningful gaps persist that warrant targeted institutional action. Professional category was the strongest predictor of perception scores, with nurses scoring substantially lower than physicians, pharmacists, and dentists across all analyses. Mechanistic understanding of resistance, particularly regarding broad-spectrum antibiotic use and the inadequacy of pharmaceutical pipelines as a long-term solution, was comparatively weak across all groups. Perception scores declined through mid-career experience levels before recovering among senior staff, suggesting that pre-registration AMR education is not being adequately reinforced during clinical practice.

These findings argue for profession-specific educational interventions directed primarily at nursing staff, mandatory stewardship re-engagement at defined career stages, and stronger integration of pharmacist-led clinical review within ward-based practice. Addressing these gaps systematically, within the framework of Pakistan's National Action Plan on AMR, represents a feasible and evidence-informed step toward reducing inappropriate antimicrobial use at the institutional level.

AUTHOR CONTRIBUTIONS

The corresponding author conceived and designed the study, developed the data collection instrument, supervised data collection, led the statistical analysis and interpretation, and drafted the manuscript. All co-authors contributed to data collection and participated in critical revision of the manuscript for important intellectual content. All authors reviewed and approved the final version of the manuscript prior to submission.

CONFLICT OF INTEREST STATEMENT

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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