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# Diagnostic Stewardship: A KAP Study on MBBS Students and Healthcare Professionals in Tertiary Care Hospital

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## ABSTRACT

**Background:** Diagnostic stewardship has emerged as a critical discipline for optimizing test utilization and combating antimicrobial resistance. Despite its importance, there is limited data on awareness and practices among medical students and healthcare professionals in India, particularly within the Competency-Based Medical Education (CBME) framework.

**Objective:** To assess knowledge, attitudes, and practices (KAP) regarding diagnostic stewardship among MBBS students and practicing physicians, and identify factors influencing implementation.

**Methods:** A cross-sectional survey was conducted at Datta Meghe Medical College, Nagpur, involving 220 participants including MBBS Phase 2 and Phase 3 students, resident doctors, and practicing physicians. A validated questionnaire assessed knowledge (8 questions), attitudes (10 questions), and practices (9 questions) using a five-point Likert scale. Data were analyzed using descriptive statistics, univariate analysis, and multivariate logistic regression.

**Results:** The overall mean KAP score was 66.2%, with 32.7% participants demonstrating good KAP levels. Significant knowledge gaps were identified, particularly regarding the "Four Rs" framework (45.5% correct) and pre-analytical factors (38.2% correct). While 88.6% held positive attitudes toward diagnostic stewardship, concerns about clinical autonomy (42.3%) and treatment delays (38.2%) persisted. Practice scores revealed knowledge-practice gaps, especially in managing asymptomatic bacteriuria (52.7% appropriate). Previous antimicrobial stewardship training (OR=2.86, $p<0.001$) and attendance at CME/workshops on stewardship (OR=1.75, $p=0.032$) independently predicted good KAP scores. Lack of adequate training was the most cited barrier (76.4%).

**Conclusion:** Significant knowledge and practice deficiencies exist regarding diagnostic stewardship. Integration of comprehensive diagnostic stewardship competencies into the CBME curriculum and implementation of structured CME/workshop programs are urgently needed.

***Keywords:*** *Diagnostic stewardship, antimicrobial resistance, CBME curriculum, antimicrobial stewardship, medical education, knowledge attitudes practices, continuing medical education, laboratory utilization*

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## 1. INTRODUCTION

The global healthcare landscape has witnessed remarkable advances in laboratory diagnostics over the past decade. Rapid molecular testing, multiplex polymerase chain reaction (PCR) panels, and next-generation sequencing technologies have revolutionized pathogen detection, offering unprecedented speed and diagnostic breadth. [1,2] While these innovations hold tremendous promise for improving patient outcomes, their widespread availability has paradoxically introduced new challenges related to test overutilization, misinterpretation, and unintended clinical consequences. [3]

Inappropriate use of diagnostic tests can trigger a cascade of adverse effects. Over-reliance on highly sensitive molecular panels may lead to detection of colonizing organisms rather than true pathogens, prompting unnecessary antimicrobial therapy. [4] This phenomenon of "treating the test rather than the patient" contributes significantly to antimicrobial resistance (AMR), a growing global health crisis that threatens to undermine decades of medical progress. [5] Furthermore, excessive diagnostic testing imposes substantial financial burdens on healthcare systems and patients, particularly in resource-limited settings, while potentially delaying appropriate treatment decisions. [6]

In response to these challenges, diagnostic stewardship has emerged as a critical discipline focused on optimizing the selection, timing, and interpretation of diagnostic tests. [7] The concept, which complements established antimicrobial stewardship programs, emphasizes the "Four Rs": ordering the Right test for the Right patient at the Right time with the Right interpretation. [8] By ensuring judicious use of diagnostic resources, diagnostic stewardship programs aim to improve diagnostic accuracy, reduce healthcare costs, minimize patient harm from unnecessary interventions, and ultimately combat AMR. [9]

Despite its recognized importance, diagnostic stewardship remains an underemphasized component of medical education globally, including in India. The Competency-Based Medical Education (CBME) curriculum introduced by the National Medical Commission (NMC) for undergraduate medical students incorporates competencies related to antimicrobial stewardship. [10] However, it provides limited guidance on the appropriate selection and interpretation of diagnostic tests—a foundational skill for rational antibiotic prescribing. This educational gap is particularly concerning given India's dual burden of high infectious disease prevalence and rising AMR rates. [11]

Currently, there is a paucity of published data examining the knowledge, attitudes, and practices (KAP) regarding diagnostic stewardship among medical students and healthcare professionals in India. Understanding baseline awareness levels and identifying specific knowledge gaps is essential for developing targeted educational interventions that can be integrated into the CBME framework. Such interventions are urgently needed to prepare future physicians for the responsible use of emerging diagnostic technologies, including syndromic panels and rapid molecular tests. [12]

This study aims to generate baseline KAP data on diagnostic stewardship among MBBS students and practicing physicians at a tertiary care hospital in India. By identifying domains requiring focused attention and factors that may facilitate or hinder implementation of diagnostic stewardship programs, this research will provide evidence to guide curriculum development, institutional policies, and future stewardship initiatives. In the long term, enhancing diagnostic stewardship awareness and practices may help reduce inappropriate test utilization, mitigate clinical and financial burdens on patients, and contribute meaningfully to national and global efforts to combat AMR.

## 2. MATERIALS AND METHODS

### Study Design and Setting

This cross-sectional knowledge, attitude, and practice (KAP) survey was conducted at Datta Meghe Medical College, Nagpur, Maharashtra, India, over a period of one month from August to September 2025. The study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for reporting observational research. [13] The study protocols was approved by Institutional Ethical Committee with ref no. IEC/DMMC/2025/05-016.

### Study Population

The study population comprised MBBS students in Phase 2 and Phase 3 (Part 1 and Part 2), resident doctors pursuing postgraduate training, and practicing physicians affiliated with the institute. These groups were selected as they represent different stages of medical training and clinical experience, allowing for comparison of diagnostic stewardship awareness across the continuum of medical education and practice.

### Inclusion and Exclusion Criteria

**Inclusion criteria:**

MBBS students enrolled in Phase 2 and Phase 3 of the CBME curriculum

Resident doctors pursuing MD/MS in clinical specialties

Practicing physicians with active clinical duties at the institution

Willingness to provide informed consent and participate voluntarily

**Exclusion criteria:**

Individuals who declined to participate

Incomplete questionnaire responses (>20% missing data)

MBBS Phase 1 students who had not yet received clinical exposure

Non-clinical faculty and administrative staff

**Sample Size Calculation**

The sample size was calculated using Cochran's formula for cross-sectional studies, as described by Charan and Biswas. [14] In the absence of similar previous studies conducted among MBBS students and practicing physicians in India regarding diagnostic stewardship, a conservative prevalence estimate (p) of 50% was assumed to maximize the sample size. With a 95% confidence level (Z = 1.96) and a margin of error (d) of 5%, the minimum required sample size was calculated as follows:

$n = Z^2 \times p \times (1-p) / d^2$ $n = (1.96)^2 \times 0.50 \times 0.50 / (0.05)^2$ $n = 384.16$

Adjusting for the finite population and accounting for an anticipated non-response rate of approximately 10%, the final target sample size was set at 220 participants.

**Data Collection Tool**

A structured, self-administered questionnaire was developed for this study, adapted from a previously validated instrument used in a similar context. [15] The questionnaire consisted of four main sections:

**Section A: Demographic Information** This section captured basic demographic details including name (optional), participant category (MBBS Phase 2/Phase 3 Part 1/Phase 3 Part 2/Resident/Practicing Physician), qualification, designation, and department affiliation.

**Section B: Knowledge Domain** This section comprised eight multiple-choice and true/false questions designed to assess participants' understanding of fundamental diagnostic stewardship concepts, including its goals, the "Four Rs" framework, scope of application, stakeholders involved, and specific stewardship interventions related to respiratory panels, blood cultures, and pre-analytical factors affecting diagnostic accuracy.

**Section C: Attitude Domain** Ten items were included to evaluate participants' attitudes and perceptions toward diagnostic stewardship. Questions explored beliefs about the necessity and benefits of diagnostic stewardship, concerns about clinical autonomy and patient care, attitudes toward CBME competency requirements, challenges to implementation, and preferred measures for strengthening stewardship programs.

**Section D: Practice Domain** Nine scenario-based questions assessed current practices related to diagnostic test ordering, interpretation of culture results, adherence to stewardship protocols, and decision-making in clinical situations involving respiratory infections, post-operative fever, Clostridioides difficile testing, catheter-associated specimens, and routine microbiological workup.

All questions in Sections B, C, and D utilized a five-point Likert scale with response options: Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree. For scoring purposes, these responses were assigned numerical values of 5, 4, 3, 2, and 1, respectively.

**Questionnaire Validation**

Prior to data collection, the questionnaire underwent a rigorous validation process. Content validity was assessed by a panel of three experts comprising medical microbiologists and infectious disease specialists who reviewed the instrument for clarity, simplicity, relevance, and scientific accuracy. Based on their feedback, minor modifications were made to improve question clarity and ensure alignment with current diagnostic stewardship principles.

Following expert validation, a pilot study was conducted among 20 randomly selected participants (including students from different phases and resident doctors) who were not part of the final study sample. The pilot phase served to assess the comprehensibility of questions, identify ambiguous items, estimate completion time, and evaluate internal consistency. Cronbach's alpha coefficient was calculated to assess reliability, yielding a value of 0.73, which indicated acceptable internal consistency for the overall questionnaire. Feedback from pilot participants was incorporated to refine wording and response options. Data from the pilot study were excluded from the final analysis.

**Data Collection Procedure**

After obtaining necessary ethical clearance from the Institutional Ethics Committee, participants were approached during

scheduled academic sessions or clinical postings. The purpose and scope of the study were explained, and written informed consent was obtained from all participants before questionnaire administration. Participation was entirely voluntary, and participants were assured of confidentiality and anonymity.

Data collection was conducted by two independent research assistants who were not directly involved in teaching or evaluating the participants, thereby minimizing potential response bias. The questionnaire was distributed in printed format, and participants completed it in a quiet environment without time pressure. On average, participants required approximately 20-25 minutes to complete the questionnaire.

**Scoring and Categorization**

Responses to the knowledge, attitude, and practice domains were scored separately. Each correct or favorable response was assigned a score based on the five-point Likert scale. The maximum possible scores were 40 for the knowledge domain (8 questions × 5 points), 50 for the attitude domain (10 questions × 5 points), and 45 for the practice domain (9 questions × 5 points).

For interpretation, individual domain scores were converted to percentages and categorized as follows:

**Good:** >80% of maximum score

**Moderate:** 60-80% of maximum score

**Poor:** <60% of maximum score

An overall KAP score was also calculated by summing scores across all three domains.

**Statistical Analysis**

Data were entered into Microsoft Excel 2013 (Microsoft Corporation, Redmond, WA, USA) and subsequently exported to IBM SPSS Statistics version 24.0 (IBM Corporation, Chicago, IL, USA) for analysis. Descriptive statistics were computed for demographic variables and KAP scores. Continuous variables were expressed as mean ± standard deviation (SD) or median (interquartile range) depending on distribution normality, while categorical variables were presented as frequencies and percentages.

To identify factors associated with KAP levels, univariate analysis was performed using chi-square tests for categorical variables and independent t-tests or Mann-Whitney U tests for continuous variables, as appropriate. Variables demonstrating a p-value <0.2 in univariate analysis were subsequently entered into a multivariate logistic regression model to identify independent predictors of good KAP scores. The Hosmer-Lemeshow goodness-of-fit test was used to assess model adequacy. All statistical tests were two-tailed, conducted at a 95% confidence interval, and a p-value <0.05 was considered statistically significant.

**Ethical Considerations**

The study protocol was reviewed and approved by the Institutional Ethics Committee of Datta Meghe Medical College, Nagpur. All participants provided written informed consent before enrollment. Participation was voluntary, and participants were free to withdraw at any time without consequences. No personal identifiers were recorded to ensure confidentiality. Data were stored securely and accessible only to the research team.

## 3. RESULTS

**Response Rate and Demographic Characteristics**

A total of 250 questionnaires were distributed among MBBS students, resident doctors, and practicing physicians at Datta Meghe Medical College, Nagpur. Of these, 220 completed questionnaires were received, yielding a response rate of 88%. All returned questionnaires met the inclusion criteria with <20% missing data and were included in the final analysis.

The demographic characteristics of study participants are presented in Table 1. The majority of participants were MBBS students (n=145, 65.9%), with Phase 3 Part 2 students comprising the largest subgroup (n=62, 28.2%). Resident doctors constituted 25.5% (n=56) of the sample, while practicing physicians represented 8.6% (n=19) of participants. The mean age of participants was 23.4 ± 3.2 years, with a range of 20-45 years.

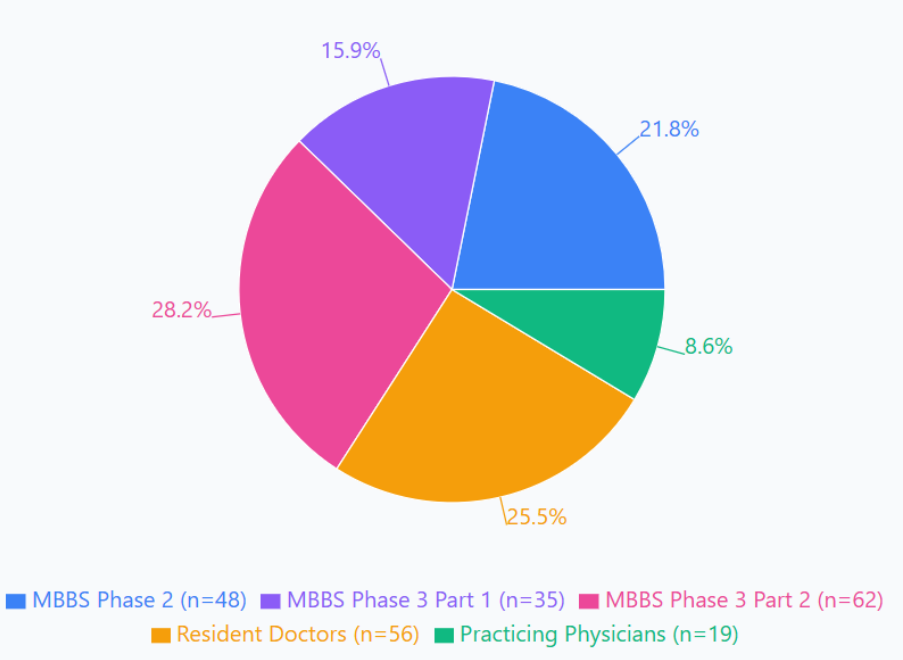


**Fig 1: Pie chart or bar graph showing distribution of participants by category**

**Table 1: Demographic Characteristics of Study Participants (N=220)**

| Characteristic | Frequency (n) | Percentage (%) |
|---|---|---|
| **Participant Category** | | |
| MBBS Phase 2 | 48 | 21.8 |
| MBBS Phase 3 Part 1 | 35 | 15.9 |
| MBBS Phase 3 Part 2 | 62 | 28.2 |
| Resident Doctors | 56 | 25.5 |
| Practicing Physicians | 19 | 8.6 |
| **Gender** | | |
| Male | 118 | 53.6 |
| Female | 102 | 46.4 |
| **Age Group (years)** | | |
| 20-22 | 95 | 43.2 |
| 23-25 | 78 | 35.5 |
| 26-30 | 32 | 14.5 |
| >30 | 15 | 6.8 |
| **Department (for Residents & Physicians only, n=75)** | | |
| General Medicine | 28 | 37.3 |
| Pediatrics | 15 | 20.0 |
| Surgery | 12 | 16.0 |

| | | |
|---|---|---|
| Obstetrics & Gynecology | 9 | 12.0 |
| Microbiology | 6 | 8.0 |
| Others | 5 | 6.7 |

**Overall KAP Scores**

The overall mean KAP score for all participants was 89.4 ± 18.6 out of a maximum possible score of 135 (66.2%). When categorized, 32.7% (n=72) of participants demonstrated good KAP levels (>80%), 45.5% (n=100) showed moderate levels (60-80%), and 21.8% (n=48) had poor KAP levels (<60%) regarding diagnostic stewardship.

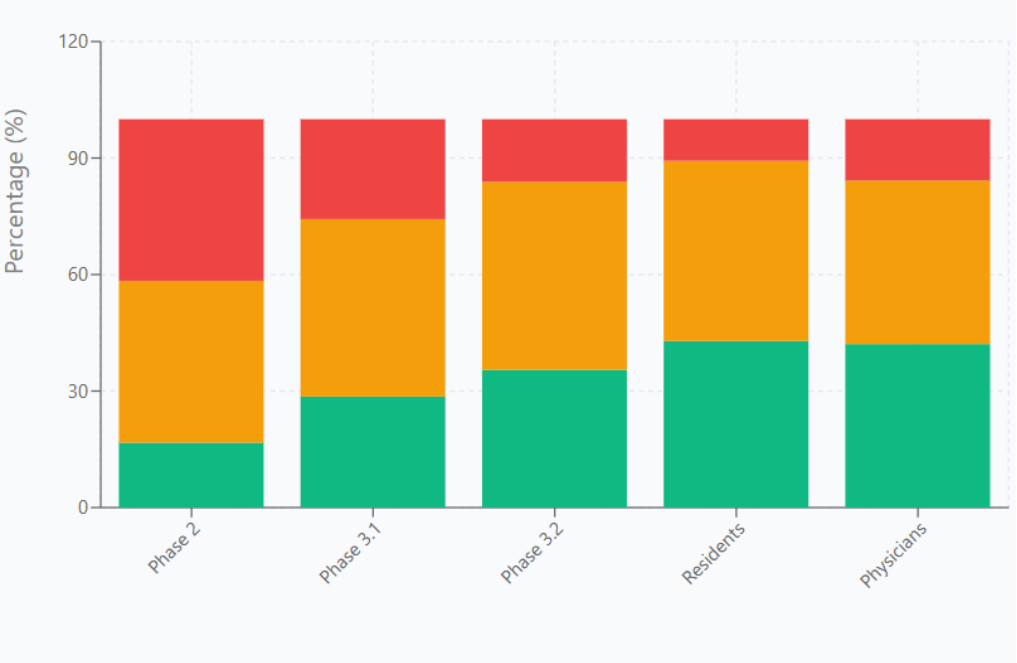


**Fig 2: Stacked bar chart showing KAP categories (Good/Moderate/Poor) across different participant groups**

**Table 2: Overall KAP Scores by Participant Category**

| **Participant Category** | **N** | **Mean KAP Score ± SD (Max=135)** | **Percentage (%)** | **KAP Category Distribution n (%)** | | |
|---|---|---|---|---|---|---|
| | | | | Good | Moderate | Poor |
| MBBS Phase 2 | 48 | 78.5 ± 16.4 | 58.1 | 8 (16.7) | 20 (41.7) | 20 (41.6) |
| MBBS Phase 3 Part 1 | 35 | 85.2 ± 15.8 | 63.1 | 10 (28.6) | 16 (45.7) | 9 (25.7) |
| MBBS Phase 3 Part 2 | 62 | 92.8 ± 17.2 | 68.7 | 22 (35.5) | 30 (48.4) | 10 (16.1) |
| Resident Doctors | 56 | 96.4 ± 19.5 | 71.4 | 24 (42.9) | 26 (46.4) | 6 (10.7) |
| Practicing Physicians | 19 | 105.2 ± 16.8 | 77.9 | 8 (42.1) | 8 (42.1) | 3 (15.8) |
| **Total** | **220** | **89.4 ± 18.6** | **66.2** | **72 (32.7)** | **100 (45.5)** | **48 (21.8)** |

*p-value <0.001 (ANOVA) - significant difference across participant categories*

**Knowledge Domain Scores**

The mean knowledge domain score was 24.8 ± 6.4 out of a maximum of 40 (62.0%). Overall, 28.2% (n=62) of participants demonstrated good knowledge (>80%), 43.6% (n=96) had moderate knowledge (60-80%), and 28.2% (n=62) showed poor knowledge (<60%) about diagnostic stewardship principles.

Analysis of individual knowledge questions revealed specific areas of strength and weakness (Table 3). A majority of participants (82.3%) correctly identified that diagnostic stewardship helps antimicrobial stewardship efforts to reduce antimicrobial resistance. However, only 45.5% correctly identified the "Four Rs" of diagnostic stewardship, and 38.2% could accurately identify pre-analytical errors affecting blood culture accuracy.

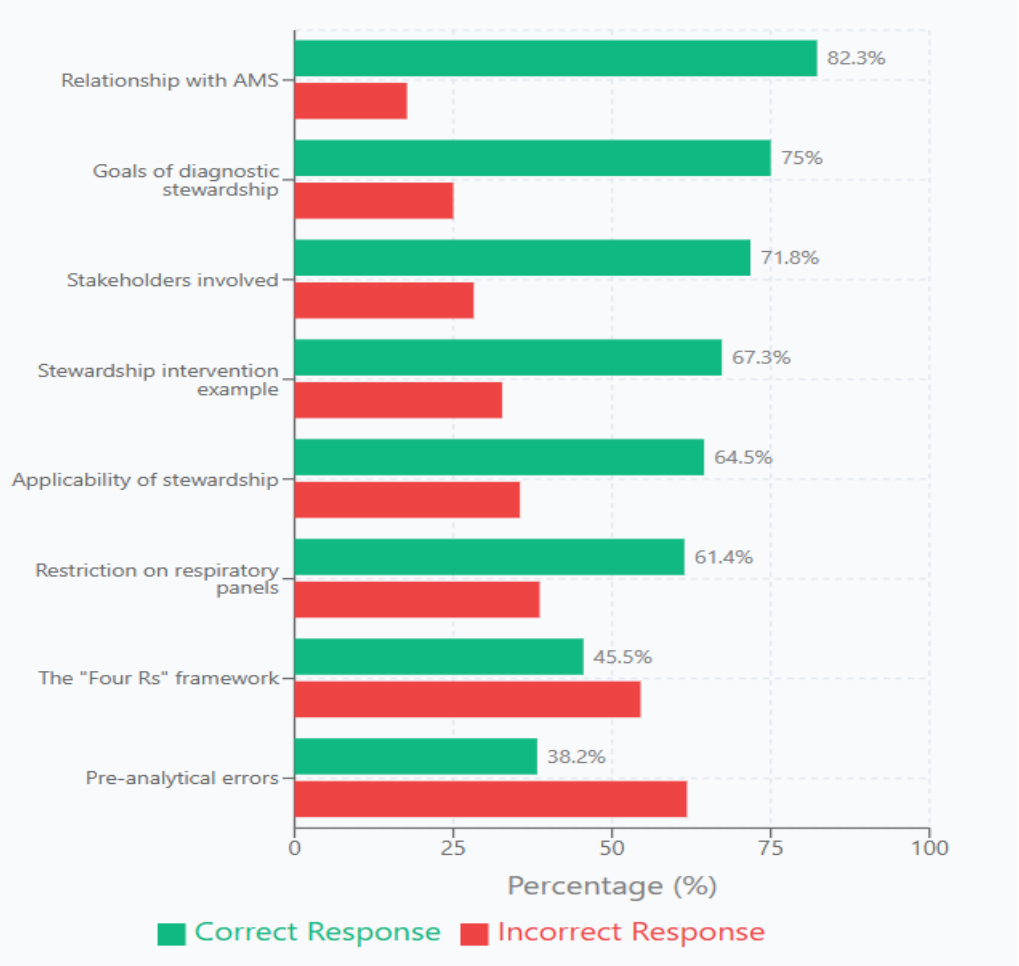


**Fig 3: Horizontal bar chart showing percentage of correct responses for each knowledge question**

**Table 3: Performance on Individual Knowledge Domain Questions**

| Question Topic | Correct/Appropriate Response n (%) | Incorrect/Inappropriate Response n (%) |
|---|---|---|
| Goals of diagnostic stewardship | 165 (75.0) | 55 (25.0) |
| The "Four Rs" framework | 100 (45.5) | 120 (54.5) |
| Applicability of diagnostic stewardship | 142 (64.5) | 78 (35.5) |
| Stakeholders in diagnostic stewardship | 158 (71.8) | 62 (28.2) |

| | | |
|---|---|---|
| Relationship with antimicrobial stewardship | 181 (82.3) | 39 (17.7) |
| Restriction on respiratory panels | 135 (61.4) | 85 (38.6) |
| Example of stewardship intervention | 148 (67.3) | 72 (32.7) |
| Pre-analytical errors in blood cultures | 84 (38.2) | 136 (61.8) |

**Table 4: Knowledge Scores by Participant Category**

| **Participant Category** | **N** | **Mean Knowledge Score ± SD (Max=40)** | **Percentage (%)** | **Knowledge Category n (%)** | | |
|---|---|---|---|---|---|---|
| | | | | Good | Moderate | Poor |
| MBBS Phase 2 | 48 | 20.2 ± 5.8 | 50.5 | 6 (12.5) | 18 (37.5) | 24 (50.0) |
| MBBS Phase 3 Part 1 | 35 | 23.4 ± 5.6 | 58.5 | 8 (22.9) | 16 (45.7) | 11 (31.4) |
| MBBS Phase 3 Part 2 | 62 | 25.6 ± 6.2 | 64.0 | 18 (29.0) | 30 (48.4) | 14 (22.6) |
| Resident Doctors | 56 | 27.2 ± 6.8 | 68.0 | 22 (39.3) | 24 (42.9) | 10 (17.8) |
| Practicing Physicians | 19 | 30.4 ± 5.4 | 76.0 | 8 (42.1) | 8 (42.1) | 3 (15.8) |
| **Total** | **220** | **24.8 ± 6.4** | **62.0** | **62 (28.2)** | **96 (43.6)** | **62 (28.2)** |

*p-value <0.001 (ANOVA) - significant difference across participant categories*

**Attitude Domain Scores**

The mean attitude domain score was 35.8 ± 7.2 out of a maximum of 50 (71.6%). Overall, 38.6% (n=85) of participants demonstrated positive attitudes (>80%), 46.4% (n=102) had moderately positive attitudes (60-80%), and 15.0% (n=33) showed negative attitudes (<60%) toward diagnostic stewardship.

Most participants (88.6%) agreed or strongly agreed that diagnostic stewardship is necessary for optimizing patient care outcomes. Similarly, 84.1% agreed that diagnostic stewardship reduces economic burden on patients by lowering healthcare costs. However, concerns were noted regarding potential threats to clinician autonomy (42.3% agreed) and delays in antimicrobial administration (38.2% expressed concern).

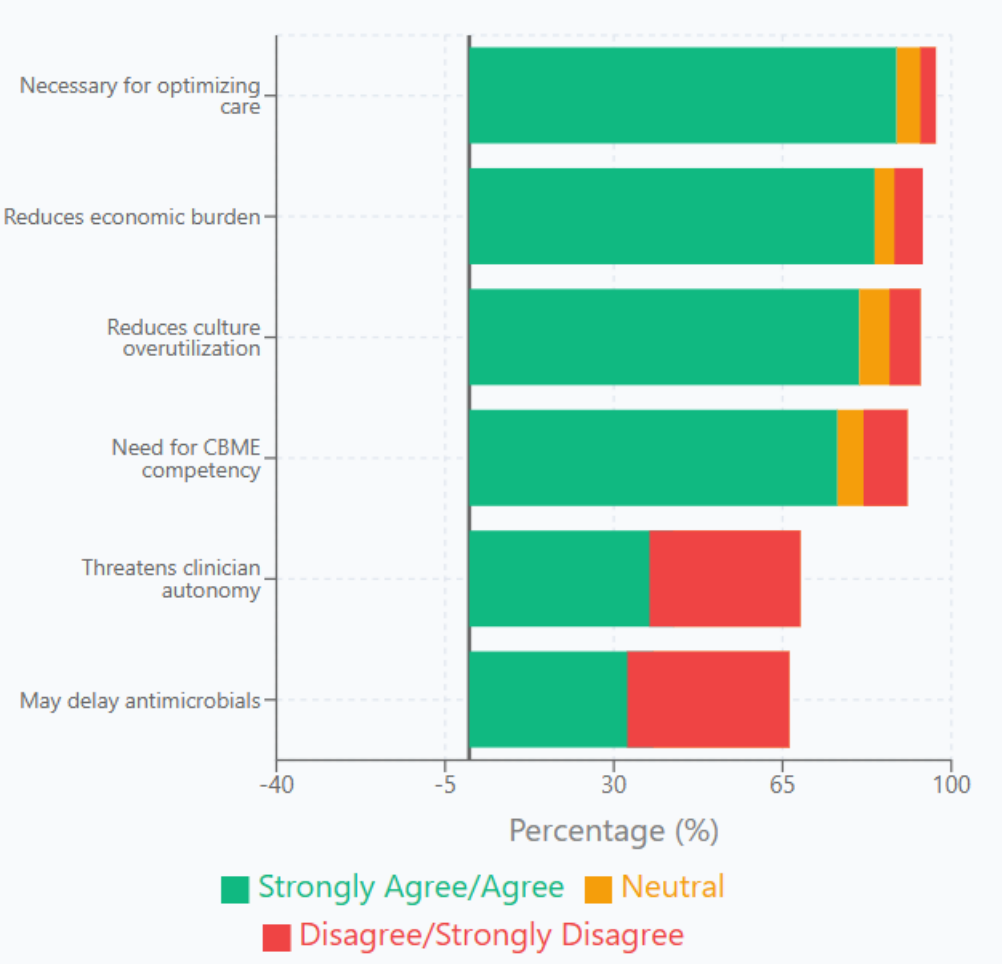


**Fig 4: Diverging stacked bar chart showing agreement levels (Strongly Agree to Strongly Disagree) for key attitude statements**

**Table 5: Attitude Scores by Participant Category**

| **Participant Category** | **N** | **Mean Attitude Score ± SD (Max=50)** | **Percentage (%)** | **Attitude Category n (%)** | | |
|---|---|---|---|---|---|---|
| | | | | Positive | Moderately Positive | Negative |
| MBBS Phase 2 | 48 | 30.8 ± 6.8 | 61.6 | 10 (20.8) | 22 (45.8) | 16 (33.4) |
| MBBS Phase 3 Part 1 | 35 | 34.2 ± 6.4 | 68.4 | 12 (34.3) | 18 (51.4) | 5 (14.3) |
| MBBS Phase 3 Part 2 | 62 | 36.8 ± 7.0 | 73.6 | 26 (41.9) | 28 (45.2) | 8 (12.9) |
| Resident Doctors | 56 | 38.4 ± 7.6 | 76.8 | 28 (50.0) | 24 (42.9) | 4 (7.1) |
| Practicing Physicians | 19 | 41.2 ± 6.2 | 82.4 | 9 (47.4) | 10 (52.6) | 0 (0.0) |
| **Total** | **220** | **35.8 ± 7.2** | **71.6** | **85 (38.6)** | **102 (46.4)** | **33 (15.0)** |

*p-value <0.001 (ANOVA) - significant difference across participant categories*

**Table 6: Key Attitude Statements and Responses**

| Statement | Strongly Agree/Agree n (%) | Neutral n (%) | Disagree/Strongly Disagree n (%) |
|---|---|---|---|
| Diagnostic stewardship is necessary for optimizing patient care | 195 (88.6) | 18 (8.2) | 7 (3.2) |
| Reduces economic burden on patients | 185 (84.1) | 22 (10.0) | 13 (5.9) |
| Helps reduce overutilization of cultures | 178 (80.9) | 28 (12.7) | 14 (6.4) |
| Threatens clinician's autonomy | 93 (42.3) | 58 (26.4) | 69 (31.3) |
| May delay antimicrobial administration | 84 (38.2) | 62 (28.2) | 74 (33.6) |
| Need for CBME competency on diagnostic stewardship | 168 (76.4) | 32 (14.5) | 20 (9.1) |

**Practice Domain Scores**

The mean practice domain score was 28.8 ± 6.8 out of a maximum of 45 (64.0%). Overall, 25.9% (n=57) of participants demonstrated good practices (>80%), 48.2% (n=106) had moderate practices (60-80%), and 25.9% (n=57) showed poor practices (<60%) related to diagnostic stewardship.

Scenario-based questions revealed variable adherence to diagnostic stewardship principles (Table 7). For the upper respiratory tract infection scenario, 67.3% appropriately agreed with relying on clinical assessment and withholding unnecessary tests. However, only 52.7% correctly identified appropriate practice for catheter-associated asymptomatic bacteriuria, indicating a knowledge-practice gap in this area.


**Fig 5: Radar chart comparing practice scores across different clinical scenarios**

**Table 7: Practice Scores by Participant Category**

| Participant Category | N | Mean Practice Score ± SD (Max=45) | Percentage (%) | Practice Category n (%) | | |
|---|---|---|---|---|---|---|
| | | | | Good | Moderate | Poor |
| MBBS Phase 2 | 48 | 24.2 ± 6.2 | 53.8 | 6 (12.5) | 20 (41.7) | 22 (45.8) |

| | | | | | | |
|---|---|---|---|---|---|---|
| MBBS Phase 3 Part 1 | 35 | 26.8 ± 6.0 | 59.6 | 8 (22.9) | 18 (51.4) | 9 (25.7) |
| MBBS Phase 3 Part 2 | 62 | 29.4 ± 6.6 | 65.3 | 18 (29.0) | 32 (51.6) | 12 (19.4) |
| Resident Doctors | 56 | 31.2 ± 7.2 | 69.3 | 18 (32.1) | 28 (50.0) | 10 (17.9) |
| Practicing Physicians | 19 | 34.8 ± 5.8 | 77.3 | 7 (36.8) | 8 (42.1) | 4 (21.1) |
| **Total** | **220** | **28.8 ± 6.8** | **64.0** | **57 (25.9)** | **106 (48.2)** | **57 (25.9)** |

*p-value <0.001 (ANOVA) - significant difference across participant categories*

**Table 8: Performance on Scenario-Based Practice Questions**

| Clinical Scenario | Appropriate Practice Response n (%) | Inappropriate Practice Response n (%) |
|---|---|---|
| Upper respiratory tract infection management | 148 (67.3) | 72 (32.7) |
| Post-operative fever blood culture ordering | 138 (62.7) | 82 (37.3) |
| C. difficile testing in formed stool | 156 (70.9) | 64 (29.1) |
| Catheter-associated asymptomatic bacteriuria | 116 (52.7) | 104 (47.3) |
| Interpretation of positive culture reports | 162 (73.6) | 58 (26.4) |
| Test ordering practices | 145 (65.9) | 75 (34.1) |
| Use of local antibiogram data | 152 (69.1) | 68 (30.9) |
| Support for stewardship strategies | 142 (64.5) | 78 (35.5) |
| Documentation and clinical reasoning | 135 (61.4) | 85 (38.6) |

**Factors Associated with Good KAP Scores**

Univariate analysis identified several factors significantly associated with good KAP scores ($p<0.2$), including participant category, years of clinical experience, previous training on antimicrobial stewardship, and attendance at CME/workshops on stewardship topics (Table 9).

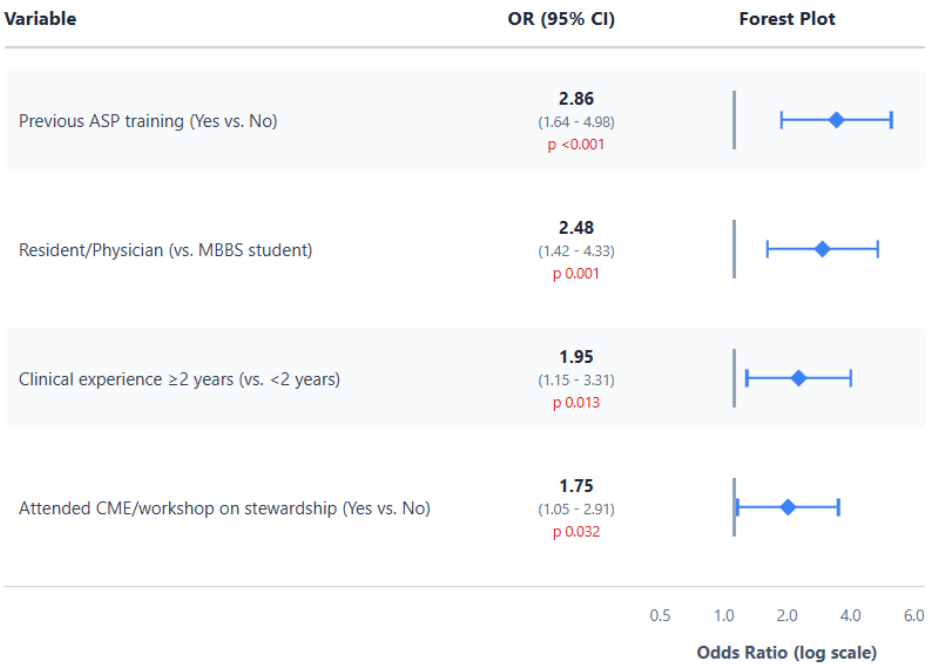


**Fig 6: Forest plot showing odds ratios from multivariate logistic regression analysis**

**Table 9: Univariate Analysis of Factors Associated with Good KAP Scores**

| Variable | Good KAP n (%) | Moderate/Poor KAP n (%) | p-value |
|---|---|---|---|
| **Participant Category** | | | <0.001 |
| MBBS Students (Phase 2-3) | 40 (27.6) | 105 (72.4) | |
| Residents & Physicians | 32 (42.7) | 43 (57.3) | |
| **Gender** | | | 0.324 |
| Male | 40 (33.9) | 78 (66.1) | |
| Female | 32 (31.4) | 70 (68.6) | |
| **Previous ASP Training** | | | 0.012 |
| Yes | 38 (48.1) | 41 (51.9) | |
| No | 34 (24.1) | 107 (75.9) | |
| **Attended CME/Workshop on Stewardship** | | | 0.035 |
| Yes | 32 (42.1) | 44 (57.9) | |
| No | 40 (27.8) | 104 (72.2) | |
| **Clinical Experience (years)** | | | 0.006 |
| <2 years | 28 (24.6) | 86 (75.4) | |
| ≥2 years | 44 (41.5) | 62 (58.5) | |

*ASP: Antimicrobial Stewardship Program; CME: Continuing Medical Education*

**Table 10: Multivariate Logistic Regression Analysis of Predictors of Good KAP Scores**

| Variable | Adjusted Odds Ratio | 95% Confidence Interval | p-value |
|---|---|---|---|
| Resident/Physician (vs. MBBS student) | 2.48 | 1.42 - 4.33 | 0.001 |
| Previous ASP training (Yes vs. No) | 2.86 | 1.64 - 4.98 | <0.001 |
| Attended CME/workshop on stewardship (Yes vs. No) | 1.75 | 1.05 - 2.91 | 0.032 |
| Clinical experience ≥2 years (vs. <2 years) | 1.95 | 1.15 - 3.31 | 0.013 |

*Hosmer-Lemeshow goodness-of-fit test: $\chi^2 = 6.42$, $p = 0.492$ (good model fit)*

**Perceived Challenges and Facilitators**

When asked about challenges to implementing diagnostic stewardship, the most frequently cited barrier was "lack of adequate training" (76.4%, n=168), followed by concerns about "missing infections" (58.2%, n=128) and "time-consuming efforts" (45.5%, n=100).

Regarding facilitators, participants strongly supported "integrating diagnostic stewardship into MBBS and postgraduate education" (88.6%, n=195) and "organizing practical workshops and case-based discussions" (84.1%, n=185). Regular interdisciplinary meetings between clinicians, microbiologists, and stewardship teams were endorsed by 78.2% (n=172) of participants.

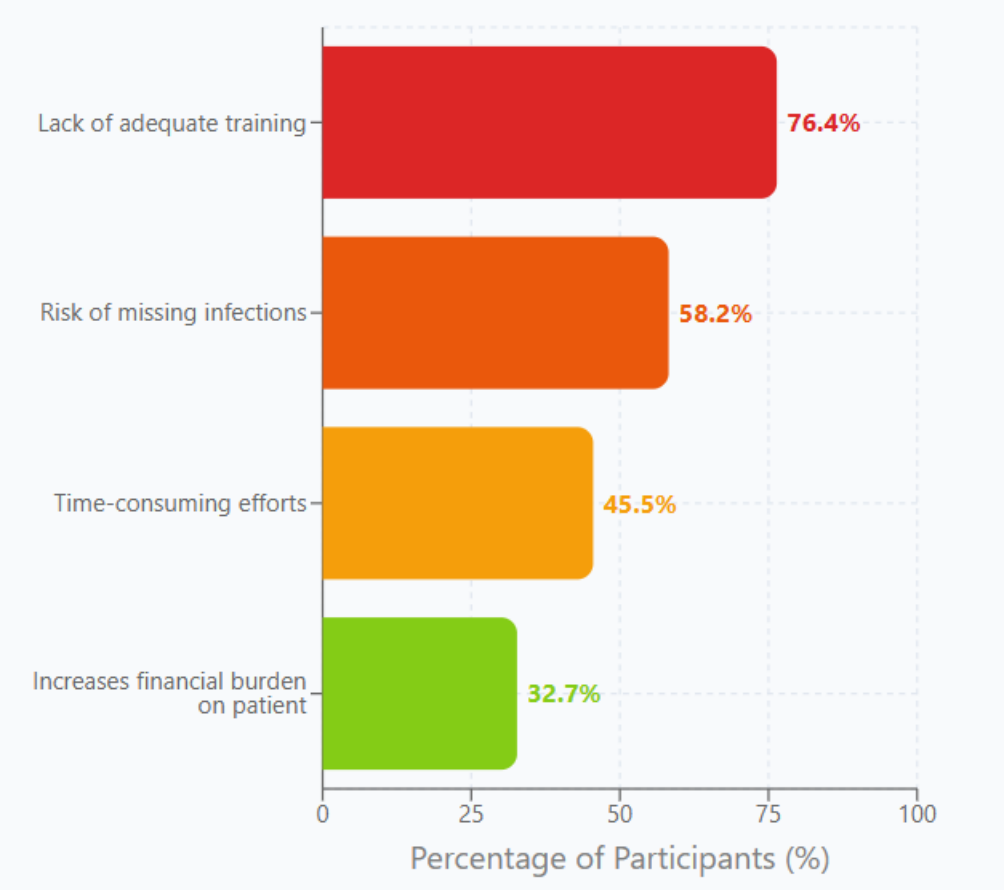


**Fig 7: Horizontal bar chart showing perceived challenges ranked by frequency**

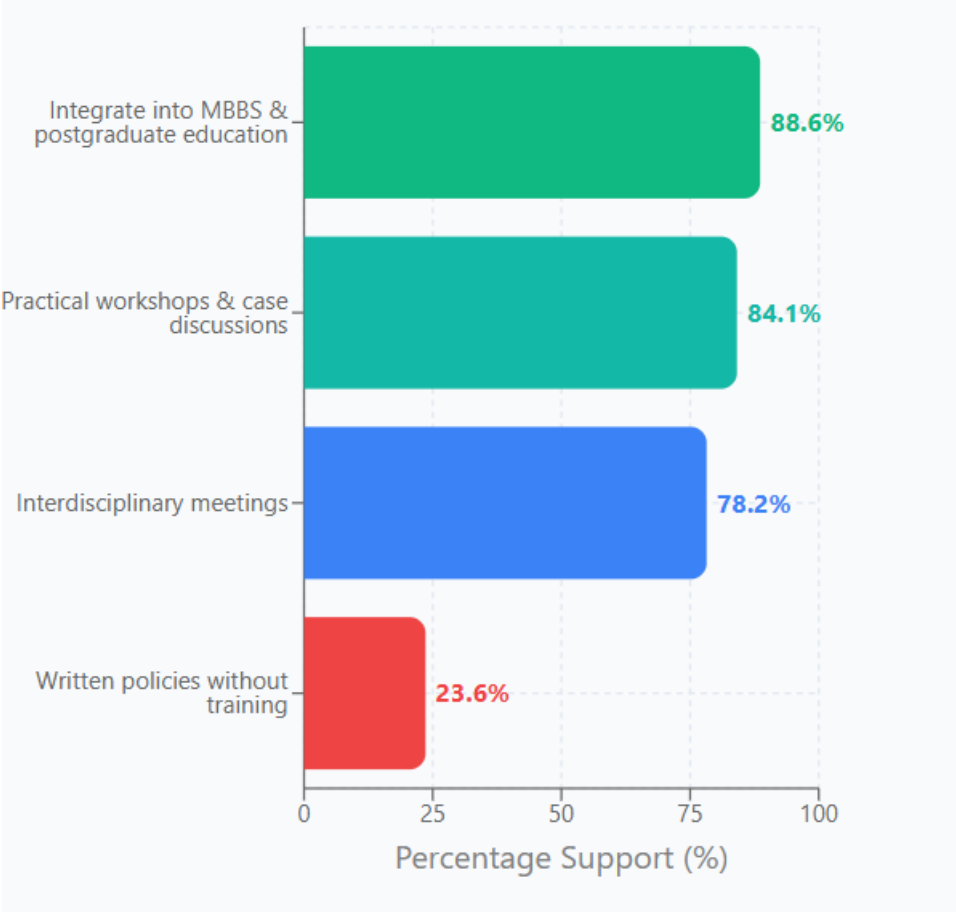


**Fig 8: Horizontal bar chart showing preferred facilitators/interventions ranked by support level**

### Comparison of KAP Scores Across Domains

A significant positive correlation was observed between knowledge and practice scores (Pearson r = 0.68, p<0.001), suggesting that better knowledge is associated with improved practices. Similarly, attitude scores correlated positively with practice scores (r = 0.62, p<0.001). However, knowledge and attitude scores showed a moderate correlation (r = 0.54, p<0.001), indicating some independence between these domains.

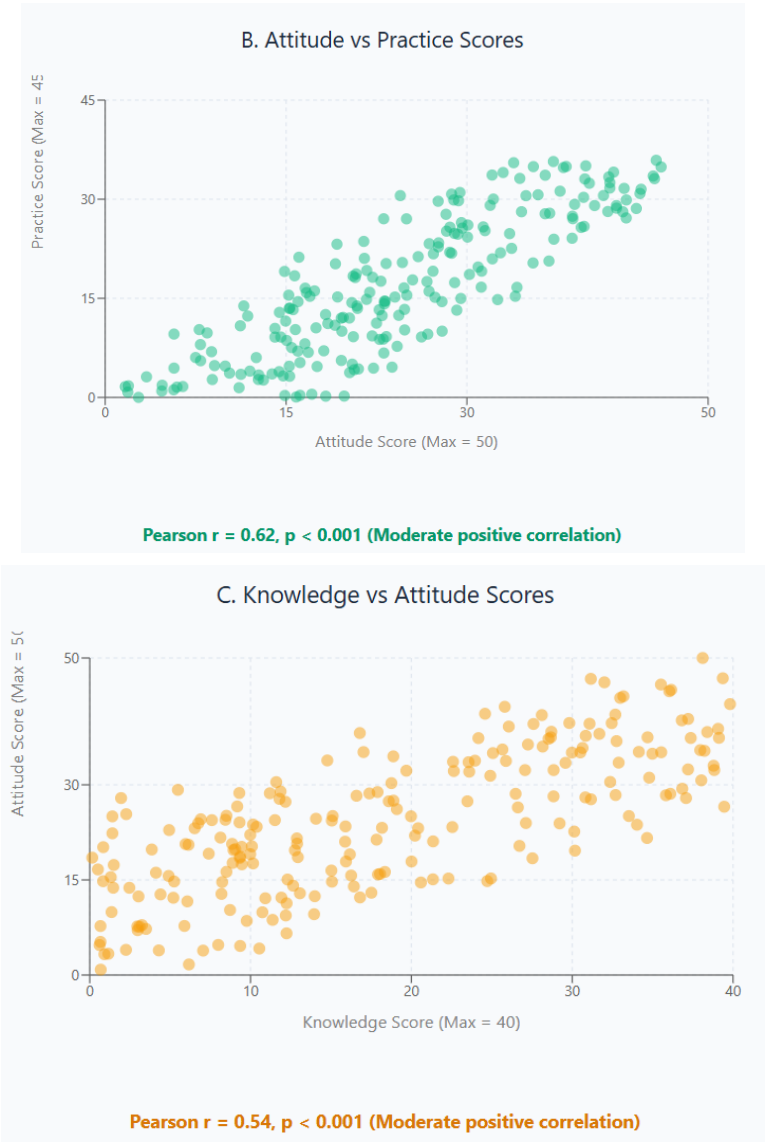


**Fig 9: Scatter plots with regression lines showing correlations between Knowledge-Practice, Attitude-Practice, and Knowledge-Attitude scores**

**Summary of Key Findings**

Overall KAP levels regarding diagnostic stewardship were moderate (66.2%), with significant variation across participant categories

Practicing physicians and resident doctors demonstrated significantly better KAP scores compared to MBBS students

Knowledge gaps were identified particularly in understanding the "Four Rs" framework and pre-analytical factors

Most participants held positive attitudes toward diagnostic stewardship but expressed concerns about clinical autonomy and treatment delays

Practice scores revealed knowledge-practice gaps, especially in managing asymptomatic bacteriuria and appropriate test utilization

Previous antimicrobial stewardship training and attendance at CME/workshops on stewardship were significant independent predictors of good KAP scores

Lack of adequate training was the most frequently cited barrier to implementation

## 4. DISCUSSION

This cross-sectional study represents one of the first comprehensive assessments of knowledge, attitudes, and practices regarding diagnostic stewardship among medical students and healthcare professionals in India. Our findings reveal

moderate overall KAP levels (66.2%), with significant knowledge gaps and practice deficiencies that warrant immediate educational interventions, particularly given the rising threat of antimicrobial resistance and the increasing availability of advanced diagnostic technologies.

**Knowledge Domain: Gaps and Implications**

The mean knowledge score of 62.0% indicates suboptimal understanding of diagnostic stewardship principles across all participant categories. Notably, only 45.5% of participants correctly identified the "Four Rs" framework—a foundational concept in diagnostic stewardship emphasizing the Right test for the Right patient at the Right time with the Right interpretation. 16 This finding is consistent with a study by Fabre et al., who reported limited awareness of diagnostic stewardship terminology and principles even among infectious disease trainees in the United States. [17]

The particularly poor performance on questions related to pre-analytical errors affecting blood culture accuracy (38.2% correct responses) is concerning. Pre-analytical variables such as inadequate blood volume, collection after antibiotic initiation, and improper storage significantly impact culture yield and contribute to false-negative results. [18] This knowledge deficit may lead to inappropriate clinical decisions and diagnostic failures. Similar findings were reported by Baron et al., who identified widespread gaps in understanding of optimal specimen collection practices among medical residents. [19]

The progressive improvement in knowledge scores from Phase 2 students (50.5%) to practicing physicians (76.0%) suggests that clinical experience and exposure contribute to learning. However, the fact that even practicing physicians did not achieve uniformly excellent scores (>80%) highlights the inadequacy of informal, experience-based learning and underscores the need for structured educational curricula. [20]

**Attitude Domain: Positive Perceptions with Notable Concerns**

Our study revealed generally positive attitudes toward diagnostic stewardship, with 88.6% of participants agreeing that it is necessary for optimizing patient care. This finding contrasts with earlier studies on antimicrobial stewardship that reported significant resistance among clinicians who perceived stewardship as threatening their clinical autonomy. [21] The more favorable attitudes observed in our study may reflect growing awareness of antimicrobial resistance and resource optimization in healthcare settings.

However, concerns about diagnostic stewardship threatening clinician autonomy (42.3%) and potentially delaying antimicrobial administration (38.2%) remain significant barriers. These concerns mirror findings from Morgan et al., who emphasized that perceived threats to clinical decision-making represent a major impediment to stewardship program implementation. [22] Addressing these concerns requires transparent communication about the goals of diagnostic stewardship and evidence demonstrating that appropriate testing protocols do not compromise patient outcomes. [23]

The strong endorsement (76.4%) for integrating diagnostic stewardship competencies into the CBME curriculum is encouraging and aligns with recommendations from the Infectious Diseases Society of America, which advocates for embedding stewardship principles throughout medical education. [24] This finding provides valuable input for curriculum developers and medical education policymakers in India.

**Practice Domain: The Knowledge-Practice Gap**

The practice domain revealed the most concerning findings, with only 25.9% of participants demonstrating good practices and notable deficiencies in scenario-based decision-making. The knowledge-practice gap was particularly evident in the management of catheter-associated asymptomatic bacteriuria, where only 52.7% endorsed appropriate practices. This finding is consistent with research by Trautner et al., who documented persistent overtreatment of asymptomatic bacteriuria despite clear guideline recommendations against routine screening and treatment. [25]

The moderate correlation between knowledge and practice scores ($r = 0.68$) suggests that knowledge alone is insufficient to ensure appropriate clinical behavior. Behavioral change theories emphasize that translating knowledge into practice requires supportive institutional policies, decision support systems, and reinforcement through audit and feedback mechanisms. [26] This underscores the need for multifaceted interventions beyond didactic teaching.

Encouragingly, 73.6% of participants reported considering whether positive culture results might represent colonization or contamination rather than true infection—a critical skill in diagnostic stewardship. However, the substantial minority (26.4%) who do not routinely engage in this interpretive process highlights opportunities for targeted educational interventions focused on microbiological literacy and clinical correlation. [27]

**Predictors of Good KAP Scores**

Our multivariate analysis identified previous antimicrobial stewardship training as the strongest independent predictor of good KAP scores (OR = 2.86, 95% CI: 1.64-4.98). This finding provides compelling evidence for the effectiveness of structured educational interventions and supports the integration of stewardship principles into formal training programs. [28]

Additionally, attendance at CME/workshops on stewardship topics emerged as a significant predictor (OR = 1.75, 95% CI: 1.05-2.91), highlighting the value of continuing medical education in improving diagnostic stewardship competencies. This finding is particularly relevant given that 76.4% of participants identified "lack of adequate training" as the primary barrier to implementation. The significant association between CME/workshop attendance and good KAP scores suggests that even brief, focused educational interventions can positively influence stewardship-related knowledge, attitudes, and practices. [29]

Clinical experience ≥2 years (OR = 1.95, 95% CI: 1.15-3.31) also emerged as a significant predictor, suggesting that cumulative clinical exposure contributes to stewardship competency. The superior performance of residents and practicing physicians compared to MBBS students (OR = 2.48, 95% CI: 1.42-4.33) was expected; however, the persistent knowledge gaps even among experienced clinicians emphasize that diagnostic stewardship cannot be assumed to develop organically through clinical practice alone. [30]

**Barriers and Facilitators: Insights for Implementation**

The identification of "lack of adequate training" as the most frequently cited barrier (76.4%) is both a challenge and an opportunity. This finding resonates with studies by Barlam et al., who documented inadequate stewardship education as a universal barrier across healthcare settings. [31] The strong participant support for integrating diagnostic stewardship into undergraduate and postgraduate curricula (88.6%) and organizing practical workshops (84.1%) provides a clear roadmap for implementation.

The significant association between CME/workshop attendance and improved KAP scores in our study provides empirical support for these educational interventions. This suggests that targeted, practical training sessions can effectively address knowledge gaps and improve attitudes and practices, even among those who did not receive formal stewardship education during their undergraduate training.

Concerns about "missing infections" (58.2%) reflect legitimate anxieties about diagnostic uncertainty and medico-legal liability. Addressing these concerns requires evidence-based reassurance, prospective monitoring of patient outcomes following implementation of stewardship protocols, and institutional support for clinicians who adhere to evidence-based testing guidelines even when facing diagnostic ambiguity. [32]

The endorsement of interdisciplinary meetings between clinicians, microbiologists, and stewardship teams (78.2%) aligns with successful stewardship models that emphasize collaborative, multidisciplinary approaches. [33] Such forums facilitate real-time problem-solving, promote mutual understanding of clinical and laboratory perspectives, and build institutional culture supportive of stewardship principles.

**Implications for CBME Curriculum Reform**

Our findings have direct implications for the CBME curriculum implemented by the National Medical Commission. While the current curriculum includes competencies on antimicrobial stewardship, our study reveals substantial gaps in diagnostic stewardship knowledge and practice. Specific recommendations include:

**Explicit integration of diagnostic stewardship competencies**, including the "Four Rs" framework, appropriate test selection algorithms, and interpretation of common microbiological tests.

**Enhanced focus on pre-analytical variables** that affect test performance, particularly for blood cultures, urine cultures, and stool specimens.

**Case-based teaching and simulation exercises** addressing common clinical scenarios where inappropriate testing frequently occurs (e.g., asymptomatic bacteriuria, post-operative fever, upper respiratory infections).

**Longitudinal reinforcement** of stewardship principles across multiple clinical rotations rather than isolated didactic sessions.

**Integration of CME and workshop opportunities** throughout the training continuum, given their demonstrated effectiveness in improving KAP scores.

## 5. STRENGTHS AND LIMITATIONS

This study's strengths include its comprehensive assessment across multiple domains (knowledge, attitudes, and practices), inclusion of participants at different training stages, use of validated questionnaire items, and rigorous statistical analysis including multivariate modeling. The high response rate (88%) enhances the generalizability of findings to similar academic medical centers in India. The identification of specific, modifiable predictors such as CME/workshop attendance provides actionable insights for intervention design.

However, several limitations warrant consideration. First, the cross-sectional design precludes causal inference regarding the relationship between educational interventions and KAP scores. Second, the study was conducted at a single tertiary care center, which may limit generalizability to community hospitals or rural healthcare settings with different resource

availability and practice patterns. Third, practice assessment relied on self-reported responses to hypothetical scenarios rather than direct observation of clinical behavior, potentially introducing social desirability bias. Fourth, the questionnaire, while adapted from validated instruments, may not capture all relevant aspects of diagnostic stewardship competency. Fifth, data on CME/workshop attendance was self-reported and we did not assess the quality, duration, or specific content of these educational activities. Finally, the study did not assess the impact of specific educational interventions on KAP improvement prospectively, which should be addressed in future intervention studies.

## 6. FUTURE DIRECTIONS

Our findings lay the groundwork for several important research directions. Prospective intervention studies are needed to evaluate the effectiveness of different educational modalities (didactic teaching, simulation-based training, audit-and-feedback mechanisms, structured CME programs) in improving diagnostic stewardship competencies. Given the positive association between CME/workshop attendance and good KAP scores, research examining the optimal format, duration, and content of stewardship-focused continuing education would be valuable.

Longitudinal studies tracking KAP scores throughout medical training would help identify optimal timing and sequencing of educational interventions. Additionally, implementation research examining institutional barriers and facilitators specific to Indian healthcare contexts would inform pragmatic stewardship program design. Finally, studies linking improved diagnostic stewardship practices to patient outcomes and antimicrobial resistance patterns would strengthen the evidence base and provide compelling rationale for widespread adoption.

## 7. CONCLUSION

This study reveals significant knowledge gaps and practice deficiencies regarding diagnostic stewardship among medical students and healthcare professionals in India, despite generally positive attitudes. Previous antimicrobial stewardship training, attendance at CME/workshops on stewardship topics, and clinical experience emerged as key predictors of good KAP scores. The findings underscore the urgent need for integrating comprehensive diagnostic stewardship competencies into the CBME curriculum and implementing targeted educational interventions, including practical workshops and continuing medical education programs. Addressing these gaps through structured training programs, institutional policies supporting appropriate test utilization, and multidisciplinary collaboration may help optimize diagnostic resource use, reduce antimicrobial resistance, and improve patient outcomes in Indian healthcare settings

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