



Original Article

Benefits of Elective Programs for Final-Year MBBS Students in the Microbiology Laboratory: A Trial of ABST-AMR-AMSP and Biomedical Waste Management Electives

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ABSTRACT

Background: Elective programs provide focused opportunities for students to develop advanced laboratory skills and professional competencies beyond core curriculum requirements^{6,7}. In microbiology education, such electives can enhance clinical relevance and address emerging public health priorities, including antimicrobial resistance (AMR) and infection control. **Methods:** This study evaluated the educational impact of two parallel microbiology electives conducted for final-year undergraduate students of GMERS Medical College Godhra. Elective 1 focused on Antibiotic Susceptibility Testing (ABST), Antimicrobial Resistance (AMR), and Antimicrobial Stewardship Programs (AMSP), while Elective 2 focused on Biomedical Waste Management (BMW). A total of twelve students participated (six per elective) in a structured 2 weeks program comprising theoretical instruction, hands-on laboratory sessions, and guided discussions. Student performance was assessed using pre- and post-tests, practical skill scoring rubrics, and structured qualitative feedback questionnaires^{6,9}. **Results:** All twelve students demonstrated higher post-test scores compared to pre-test assessments, with statistically significant improvement in knowledge and practical competencies ($p < 0.05$). Participants showed enhanced technical proficiency, improved understanding of AST interpretation, AMR mechanisms, AMSP roles, and biomedical waste handling, along with increased confidence and clinical readiness. **Conclusion:** Short-term, focused microbiology electives significantly improve laboratory skills, conceptual understanding, critical thinking, and professional confidence among final-year students. Integration of ABST-AMR-AMSP and BMW electives within undergraduate curricula is recommended to strengthen clinical relevance, antimicrobial stewardship awareness, and preparedness for modern microbiology practice.

Keywords: Elective program; antibiotic susceptibility testing; antimicrobial resistance; antimicrobial stewardship program; biomedical waste management; microbiology education.

INTRODUCTION

Competency Based Medical Education (CBME) was introduced by the National Medical Council (NMC) to ensure that medical students acquire essential competencies and skills through a structured curriculum specifying competencies, time allocation, and duration for each subject [16]. Along with changes in teaching and assessment methods, NMC introduced elective postings as Module 6 in Part 2 of the third year MBBS, a relatively new concept with limited published literature [17]. Implemented in India in 2019, elective postings aim to help students explore specialized subjects for future career selection. The primary objective is transformative learning, comprising instrumental learning, which focuses on developing

subject-specific clinical skills, and communicative learning, which emphasizes interpersonal skills and effective patient communication [18].

Laboratory competence is central to microbiology education; however, undergraduate curricula often provide limited exposure to advanced diagnostic techniques and clinically relevant practices⁸. Elective programs offer an effective means to bridge this gap by providing focused, skill-intensive training aligned with student interests and career goals^{6,7}.

To implement successfully, we need to continuously evaluate the effectiveness of the elective program and make necessary revisions based on feedback, outcomes, and challenges faced during implementation, as it begins in the medical journey. Antibiotic Susceptibility Testing (ABST) is a cornerstone of clinical microbiology, guiding antimicrobial therapy through standardized methodologies and interpretive criteria defined by CLSI and EUCAST^{1,2}. Accurate ABST is essential for optimal patient management and surveillance of resistance patterns^{3,5}.

The global rise of antimicrobial resistance (AMR) poses a major public health threat, with projections estimating up to 10 million deaths annually by 2050¹¹. In response, Antimicrobial Stewardship Programs (AMSP) have been promoted globally to optimize antimicrobial use, reduce resistance, and improve patient outcomes^{12,13}. Effective stewardship relies heavily on accurate microbiological data and close collaboration between clinicians and microbiology laboratories.

Biomedical Waste Management (BMW) is another critical yet often underemphasized component of microbiology training. Improper handling of biomedical waste contributes to occupational hazards, environmental contamination, and healthcare-associated infections⁸.

This study describes the outcomes of two concurrent microbiology electives-ABST-AMR-AMSP and Biomedical Waste Management-and evaluates their impact on students' knowledge, laboratory skills, critical thinking, and professional readiness. The present study also suggested to make the elective posting innovative as well as interesting that can help student to choose pre and para clinical subject in post graduate, as Presently, the students are more inclined towards clinical subjects.

MATERIALS AND METHODS

2.1 Study Design

This was a prospective cross-sectional study conducted from 01.12.2025 to 15.12.2025 at GMERS Medical College and General Hospital, Godhra, Gujarat, among 12 undergraduate students from a batch of 100 MBBS students (2022-2023 batch, Third MBBS Part I) who chose elective topics from different sections of the Department of Microbiology.

The 15-day elective posting was structured to include orientation, pre-test, small-group discussions, self-directed learning sessions, post-test, structured qualitative feedback, and final submission of a logbook maintained throughout the posting. The program was conducted based on principles of experiential and inquiry-driven learning. Such educational approaches have been shown to enhance skill acquisition and research readiness in microbiology students^{8,10}.

Inclusion Criteria

1. IIIrd MBBS medical students posted in the Department of Microbiology during their elective posting.
2. Medical students who willingly provided informed consent to participate in the study.

Exclusion Criteria

1. Students who did not meet the attendance requirement of at least 75% during the elective posting.

Aims & Objectives

- To Integrate diagnosis with stewardship & national AMR efforts by leaning AST, AMR & AMSP.
- To learn BMW management and enhances infection prevention awareness.
- The aim of elective posting is to give the student the chance to immerse themselves in a field of study, career stream, or profession.

2.2 Participants

Twelve final-year undergraduate students voluntarily enrolled after completing core microbiology practical courses. Students were allocated into:

- **Elective 1 (n = 6):** ABST, AMR, and AMSP
- **Elective 2 (n = 6):** Biomedical Waste Management

2.3 Program Components

Elective 1: ABST-AMR-AMSP

The elective integrated theory with hands-on laboratory exposure:

- **Theoretical instruction:**
 - Mechanisms of antimicrobial action and resistance (ESBL, MRSA, CRE)
 - Epidemiology and clinical impact of AMR^{11,12}
 - Principles, objectives, and structure of AMSP¹³
- **Hands-on training:**
 - Kirby-Bauer disc diffusion testing
 - Minimum inhibitory concentration (MIC) determination
 - Inoculum standardization and zone diameter measurement
 - Interpretation using CLSI and EUCAST guidelines^{1,2}
- **Data interpretation workshops:**
 - Analysis of culture and sensitivity reports
 - Identification of major and minor AST errors^{3,5}
 - Preparation and interpretation of antibiograms.

Table 1: The Schedule for the elective-1 posting

Day	Topic
Day 1	Orientation and Pre-Test
Day 2	Group Discussion on antimicrobial resistance pattern, AST methods and structure and principle of AMSP
Day 3	Discussion on laboratory Standard operative procedure (SOPs), sample collection & transport, Types of culture media, CLSI, EUCAST guidelines.
Day 4	Observation of sample receiving process and rejection process.
Day 5	Observation of blood culture and other sample process
Day 6	Observation of culture and sensitivity testing and biochemical reaction
Day 7	Observation of culture and sensitivity testing and biochemical reaction
Day 8	Perform sample striking on culture media and make inoculum.
Day 9	Perform sample striking on culture media and make inoculum.
Day 10	Perform Antibiotic sensitivity testing
Day 11	Perform Antibiotic sensitivity testing
Day 12	Interpretation of culture & sensitivity report using CLSI guidelines
Day 13	Understand basic knowledge of Antibiogram preparation and AMSP committee
Day 14	Hands-on preparation of antibiogram & review antibiotic policy & structure of AMSP committee. Presentation by student on this elective topic.
Day 15	Post-test and descriptive feedback form fill-up

Elective 2: Biomedical Waste Management

- **Theoretical modules:**
 - BMW rules, colour coding, and regulatory requirements
 - Infection control and occupational safety principles
- **Practical exposure:**
 - Waste segregation exercises
 - Demonstrations of handling, transport, and disposal
 - Observation of hospital BMW workflows

Table 2: The schedule for the elective-2 posting

Day	Topic
Day 1	Orientation and Pre-Test
Day 2	Group Discussion on Biomedical Waste Management, Colour coding and basic needs, Healthcare associated infection, CSSD, Universal precaution.
Day 3	Discussion on Standard operative procedure (SOPs), Hospital Infection control committee, BMW rules, Personal protective equipment, Post exposure prophylaxis.
Day 4	Observation of waste generation and segregation & transportation
Day 5	Observation of waste generation and segregation & transportation
Day 6	Observation of Infection prevention and control practice at various location in hospital.
Day 7	Observation of Infection prevention and control practice at various location in hospital.
Day 8	Involve in segregation process and proper transportation of waste to dedicated area.
Day 9	Involve in segregation process and proper transportation of waste to dedicated area.
Day 10	Evaluation of IPC practice at OPD, IPD & ICU area by filling up check list form.
Day 11	Evaluation of IPC practice at OPD, IPD & ICU area by filling up check list form.
Day 12	Visit to CSSD

Day 13	Understand basic knowledge of HIC committee & IPC audit and roles-responsibility of clinician and ICN
Day 14	Hands-on Risk assessment, corrective and preventive action BMW lapses. Presentation by student on this elective topic.
Day 15	Post-test and descriptive feedback form fill-up

2.4 Evaluation and Data Collection

Student performance was assessed using:

- **Pre- and post-test assessments** to measure knowledge gain
- **Practical skill scoring rubrics** evaluating procedural accuracy and guideline adherence
- Logbook entry required: Signed logbook entry. Preceptor signature with —Meets Expectation
- **Structured qualitative feedback forms** containing descriptive questions assessing learning outcomes, challenges, clinical relevance, and recommendations^{6,9}

RESULTS

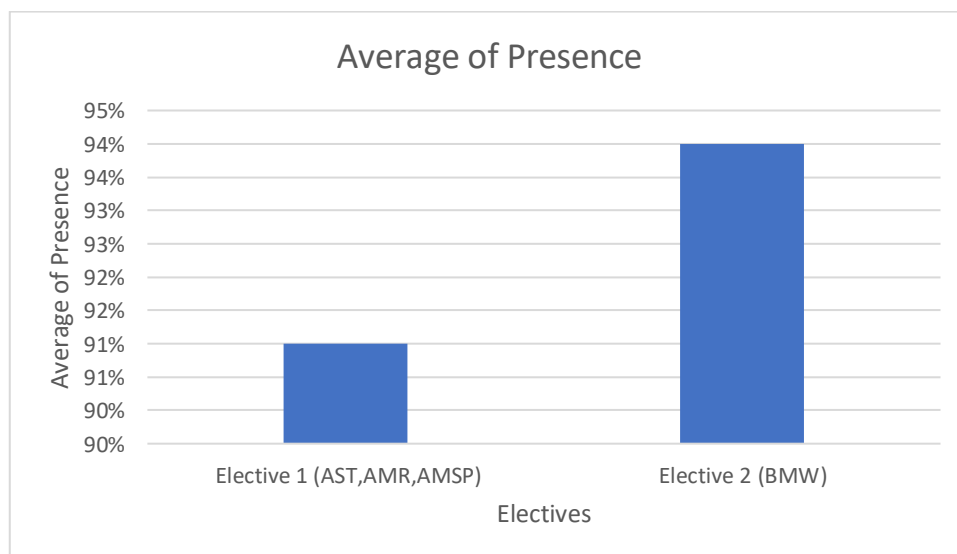
15 days duration elective program of 12 third part first MBBS students conducted in two section in Department of Microbiology. Among the 12, 6 students posted in each section. All student successfully completed elective program with average attendance rate of 91% in Elective 1 and 94% in elective 2 reflecting strong participation. Two student remain absent for 3 days, two students remain absent for 1 days in first elective, while two student remain absent 2 days, one student remain absent for 1 day in elective 2. (Fig-1)

Table- 1

Student Roll No	Present Day	Percentage
1	12	80%
21	12	80%
44	14	93%
58	14	93%
90	15	100%
93	15	100%
Average of Elective 1		91%

Table- 2

Student Roll No	Present Day	Percentage
7	15	100%
10	13	86%
22	15	100%
49	13	86%
86	14	93%
87	15	100%
Average of Elective 2		94%



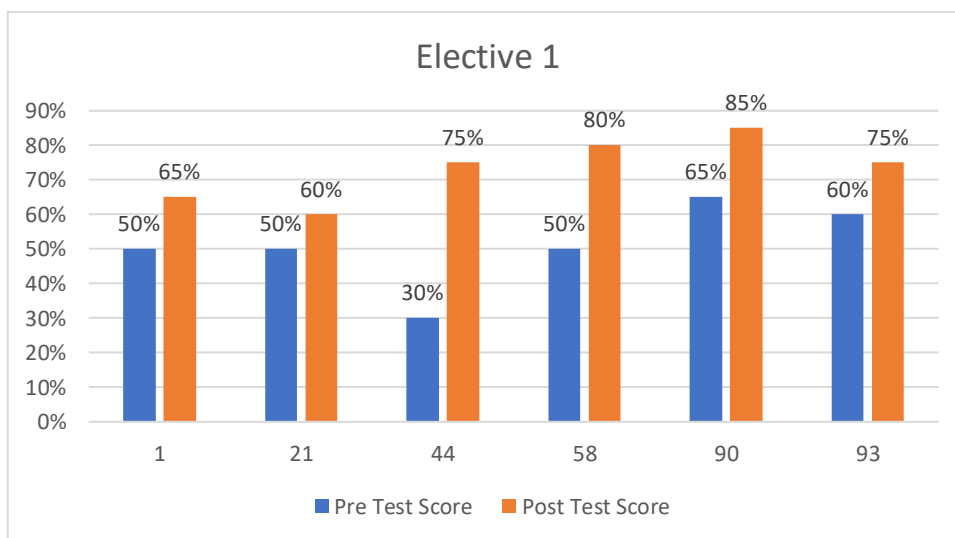
(Fig. 1)

3.1 Knowledge Gain

All twelve students achieved higher post-test scores compared to pre-test assessments, indicating significant improvement in theoretical understanding across both electives. Similar gains have been reported in elective and research-based microbiology courses^{6,10}.

Table- 3 Elective 1 (AST, AMR, AMSP) Assessment

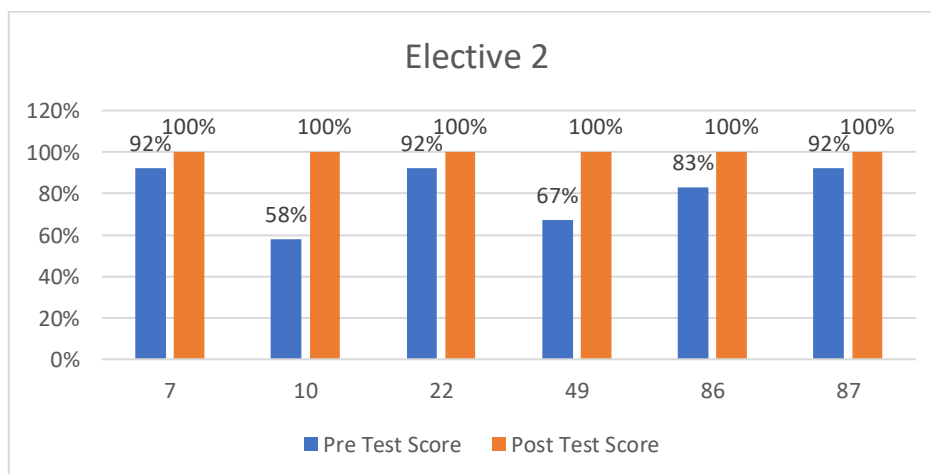
Roll number	Pre Test (20 Marks) on 01-12-2025	Post Test (20 Marks) on 15-12-2025
1	10	12
21	10	13
44	6	15
58	10	16
90	13	17
93	12	15



(Fig. 2)

Table- 4 Elective 2 (BMW) Assessment

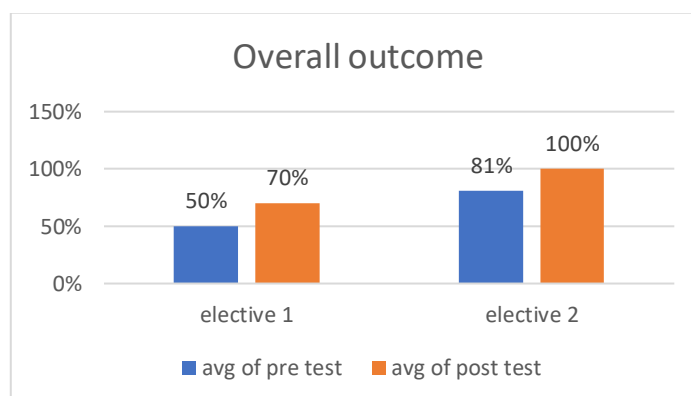
Roll number	Pre Test (12 Marks) on 01-12-2025	Post Test (12 Marks) on 15-12-2025
7	11	12
10	7	12
22	11	12
49	8	12
86	10	12
87	11	12



(Fig. 3)

Table- 5

	elective 1	elective 2
average of pre test	50%	81%
average of post test	70%	100%
Improvement %	20%	19%

**(Fig. 4)**

Overall improvement seen in elective 1 is 20% and improvement in knowledge of elective 2 is 19% as comparing result of post-test with pre-test.

3.2 Improvement in Practical Skills

Total six Students (2 Boys, 4 Girls) aged between 21-24 years were enrolled in the ABST-AMR-AMSP elective demonstrated improved aseptic technique, procedural accuracy, and interpretation of susceptibility results. Feedback of the student were recorded as various Practical skill using scoring rubrics format given below.

Table- 6 AST feedback scoring rubrics

AST	Excellent	Very Good	Good	Average	Poor
Clarity of learning objectives	66%	17%	17%	0%	0%
Understanding of Antimicrobial Susceptibility Test (AST)	50%	33%	17%	0%	0%
course content was relevant to your clinical and academic needs	33%	50%	17%	0%	0%
Hands-on exposure to Antimicrobial Susceptibility Testing (AST)	34%	33%	33%	0%	0%
Faculty guidance and supervision	68%	16%	16%	0%	0%
Prior Knowledge of AST before this Elective	16%	17%	50%	17%	0%
Knowledge of AST after this Elective	34%	50%	16%	0%	0%
Overall usefulness of this elective	34%	50%	16%	0%	0%

Most students rated the clarity of objectives and faculty guidance as excellent. Understanding and hands-on exposure to AST were rated very good to excellent by most participants. Prior knowledge of AST was moderate to average, but knowledge significantly improved after the elective. Overall, the AST elective was found to be useful.

Table- 7 AMR feedback scoring rubrics

AMR	Excellent	Very Good	Good	Average	Poor
Clarity of learning objectives	50%	34%	16%	0%	0%
Understanding of Antimicrobial Resistance (AMR)	50%	34%	16%	0%	0%
course content was relevant to your clinical and academic needs	50%	50%	0%	0%	0%
Hands-on exposure to Find resistance pattern	34%	50%	16%	0%	0%
Faculty guidance and supervision	68%	16%	16%	0%	0%
Prior Knowledge of AMR before this Elective	0%	17%	68%	17%	0%
Knowledge of AMR after this Elective	34%	50%	16%	0%	0%
Overall usefulness of this elective	50%	17%	17%	16%	0%

Learning objectives and understanding of AMR were rated excellent by most students. Course content was considered highly relevant to clinical and academic needs. Hands-on exposure to resistance pattern identification was well appreciated. Students showed clear improvement in AMR knowledge after the elective. The AMR elective was overall useful with minimal average ratings.

Table- 8 AMSP feedback scoring rubrics

AMSP	Excellent	Very Good	Good	Average	Poor
Clarity of learning objectives	50%	17%	33%	0%	0%
Understanding of Antimicrobial Stewardship Program (AMSP)	50%	17%	33%	0%	0%
course content was relevant to your clinical and academic needs	34%	34%	16%	16%	0%
Hands-on exposure to prepare Antibiogram & Antibiotic policy	34%	34%	16%	16%	0%
Faculty guidance and supervision	68%	32%	0%	0%	0%
Prior Knowledge of AMSP before this Elective	16%	0%	68%	16%	0%
Knowledge of AMSP after this Elective	17%	50%	17%	16%	0%
Overall usefulness of this elective	50%	17%	33%	0%	0%

Faculty guidance and supervision received excellent ratings from most students. Learning objectives and understanding of AMSP were rated good to excellent. Hands-on exposure to antibiogram preparation and antibiotic policy showed mixed responses. Knowledge of AMSP improved noticeably after the elective. Overall, the AMSP elective was considered useful by most participants.

These findings align with prior studies emphasizing the value of structured AST training^{6,8}. BMW elective participants showed enhanced competence in waste segregation and compliance with infection control protocols.

Table- 9 BMW feedback scoring rubrics

BMW	Excellent	Very Good	Good	Average	Poor
Understanding of BMW rules and guidelines	83%	17%	0%	0%	0%
Knowledge of waste segregation and color coding	50%	50%	0%	0%	0%
Practical exposure to BMW handling	50%	0%	50%	0%	0%
Awareness of infection control and safety measures	50%	50%	0%	0%	0%
Relevance to future clinical practice	50%	50%	0%	0%	0%
Faculty support and supervision	83%	17%	0%	0%	0%
Prior knowledge of BMW before elective	17%	0%	66%	17%	0%
knowledge of BMW after elective	50%	50%	0%	0%	0%
Overall effectiveness of this elective	83%	17%	0%	0%	0%

DISCUSSION:

Enhanced Understanding & Development of Critical Thinking

The elective was highly effective in enhancing students' understanding of Biomedical Waste (BMW) management. Most participants rated their understanding of BMW rules, faculty support, and overall effectiveness as excellent, reflecting strong teaching and supervision. Knowledge of waste segregation, infection control, and relevance to future clinical practice was rated as excellent or very good by all students, indicating comprehensive learning outcomes. Practical exposure showed some variability, suggesting scope for increased hands-on experience. Overall, the elective significantly improved students' knowledge of BMW compared to their prior understanding and was perceived as highly relevant to future clinical practice.

Post-elective feedback indicated improved awareness of AMR mechanisms and the role of microbiology laboratories in resistance surveillance, along with appropriate biomedical waste (BMW) segregation, handling, and disposal practices¹². Students demonstrated a clearer understanding of AMSP objectives, infection control measures, and the clinician's responsibility in rational antimicrobial prescribing and safe BMW management¹³. Additionally, participants reported enhanced ability to troubleshoot ambiguous results, distinguish technical errors from biological variation, and apply microbiology knowledge while adhering to biosafety and BMW regulations in clinical contexts^{3,5}. This was accompanied by increased confidence and professional identity formation, consistent with findings from inquiry-based laboratory training emphasizing biosafety and BMW compliance^{7,14,15}.

Students answered descriptive questions on learning outcomes, challenges, clinical relevance, and recommendations, providing positive feedback on the effectiveness of the elective. Their responses and suggestions are discussed below.

Table- 10 Reasons for Choosing the Elective

Reason for choosing the elective	Student Answer
Career interest	0
Skill development	58% (7/12)
Research exposure	0
Recommendation by faculty/seniors	25% (3/12)
Availability	0
Other	17% (2/12)

This table summarizes the reasons students reported for selecting the elective. The majority of students (58%) chose the elective for skill development, while 25% were influenced by faculty or senior recommendations, and 17% cited other reasons. No students selected career interest, research exposure, or availability as their reason.

Table- 11 Recommendation for Future Students

Student Answer	Recommendation of Electives to Future MBBS Students
YES	100% (12/12)
NO	0% (0/12)

All students (100%) recommended this elective, with no negative responses.

Table- 12 Intended postgraduate specialty

Intended postgraduate specialty	Student Response
Same as elective	17% (2/12)
Different	8% (1/12)
Undecided	75% (9/12)

The majority of students (75%) were undecided about their intended postgraduate specialty, indicating significant uncertainty at this stage of training. A smaller proportion planned to pursue the same specialty as their elective (17%), suggesting some positive influence of elective exposure. Only a minority (8%) intended to choose a different specialty, highlighting that electives may help guide decisions but are not the sole determinant of postgraduate career choice.

CONCLUSION:

The Biomedical Waste (BMW) management elective was highly effective in improving students' knowledge and understanding of BMW rules, waste segregation, infection control, and their importance in future clinical practice. All participants rated the learning outcomes and overall effectiveness as excellent or very good, indicating successful achievement of the elective objectives. Faculty support and supervision were also highly appreciated. Although practical exposure varied among students, the elective significantly enhanced post-training knowledge compared to prior understanding, highlighting its educational value and clinical relevance.

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