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Original Research Article

Effectiveness of Educational Intervention on Antimicrobial Resistance among Interns of a Tertiary Teaching Hospital

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Abstract: ***Background***: Antimicrobial resistance (AMR) poses a major threat globally, particularly in developing countries. Hence, this study aimed to evaluate the effectiveness of an educational intervention in improving the knowledge, attitude, practice, perceptions and prescribing confidence of medical interns regarding antimicrobial use. ***Materials and Methods:*** A web-based quasi-experimental study was conducted among interns at a tertiary teaching hospital using a pre-tested questionnaire for 3 months. The interventions were Flipped Class (FC) approach and Mini Clinical Evaluation Exercise and scores were compared using paired t-tests. ***Results***: Post-intervention knowledge scores improved from 8.04 ± 1.68 to 9.53 ± 1.70 ($p < 0.001$) and perception scores from 7.08 ± 1.51 to 7.59 ± 1.28 ($p = 0.014$). Confidence in various prescribing competencies improved significantly (56.86% to 86.27%, $p < 0.001$) and choosing correct antibiotic (72.55% to 88.24%, $p = 0.021$). ***Conclusion***: A targeted educational intervention significantly improved interns' knowledge, perception and prescribing confidence related to antimicrobics, though changes in attitudes and self-reported practices were minimal. Integration of such active learning strategies into teaching may strengthen rational prescribing behaviours.

Keywords: Medical interns, Flipped Class, Mini-CEX.

INTRODUCTION

Antimicrobial Resistance (AMR) threatens the effectiveness of core medical treatments and contributes substantially to global morbidity and mortality, with recent systematic analyses estimating millions of deaths associated with bacterial AMR in 2019 [1]. The burden was found to be high in developing countries where high infectious-disease prevalence, weaker regulatory frameworks and gaps in stewardship amplify the problem. India faces a heavy AMR load among key pathogens like Klebsiella, Acinetobacter and Staphylococcus species and an increasing number of resistant isolates from tertiary care settings [2]. Environmental, regulatory and behavioural drivers including empirical prescribing without microbiological confirmation, easy over-the-counter access to antibiotics, inadequate diagnostic capacity and limited stewardship implementation sustain this trend in India [3].

Improving the knowledge, attitudes, and practices of prescribers is crucial for containment measures because doctors make the final decisions on prescriptions. Recent research from India, however, reveals on-going deficiencies in undergraduate and pre-service training on AMR and stewardship, demonstrating that targeted educational modules might increase understanding while application improvements are still inconsistent [4].

Traditional didactic lectures improve awareness but often fail to ensure prescribing behaviour. Higher cognitive tasks and real-world clinical performance are more closely associated with active, workplace-linked learning and assessment modalities like the flipped-classroom (FC) model and Mini-Clinical Evaluation Exercise (Mini-CEX). FC has been demonstrated to increase student involvement and their sense of readiness for logical prescription in Indian medical school [5, 6]. Mini-CEX, a brief observed clinical encounter, is a feasible formative assessment tool for rational antimicrobial decision-

making into everyday clinical work [7].

Integrating these educational interventions offer a competency-focused strategy aligns with competency-based undergraduate reform and stewardship priorities. Having these in mind, this study evaluates the effectiveness of an educational intervention incorporating flipped classroom and Mini-CEX, on improving AMR-related knowledge, attitudes, and practices among medical interns in a tertiary teaching hospital.

MATERIALS AND METHODS

A web-based quasi-experimental study was conducted between the period of February 2025– April 2025 (3 months) and ethical approval was obtained from the Institutional Ethics Committee prior to the study [Ref no:09/SVMCH/IEC-Cert/Mar.25]. This study involved medical interns posted in the Department of Community Medicine at a tertiary teaching hospital. All interns during the study period were invited to participate except those who are absent consecutively for one week or did not consent for participation. A pre-designed and pre-tested questionnaire was shared via online portal to collect information, their knowledge, attitudes and practices related to antimicrobial usage, their perceptions, confidence and factors contributing to Antimicrobial Resistance (AMR). Panel of experts reviewed the questionnaire, and it was pilot tested before the study.

The questionnaire consists of:

I. Knowledge and Attitude about antibiotic usage

a Are Antibiotics safe drugs to be used?
b Is prescribing inappropriate or unnecessary antibiotics professionally unethical?
c Is empirical management by antibiotics the need of the hour to prevent resistance?
d When you have a cough and sore throat, are antimicrobials the first choice for early treatment?
e Do you prefer to prescribe an antibiotic for cough and sore throat?
f Do you prefer to prescribe an antibiotic for all episodes of diarrhea?
g Do you consult with your consultant before prescribing an antibiotic?
h Do you read standard treatment guidelines for antibiotic therapy before prescribing?
i Are there any guidelines for antibiotic followed in the hospital?
j Have you got a copy of the hospital's antibiotic guidelines?
k Do you think that there is a gap between theoretical and clinical approach in prescribing antibiotic?
l Is irrational antibiotic usage existed in India?

II. Practice

The doctor prescribes a course of antibiotic for you. After taking 2-3 doses, you start feeling better. Now,

a Do you stop taking further treatment?
b Do you save the remaining antibiotics for the next time you get sick?
c Do you discard the remaining left-over medication?
d Do you give the left-over antibiotics to your friend/roommate if they get sick?
e Do you complete the full course of treatment?
f Do you check the expiry date of the antibiotic before using it?

III. Perception on antibiotics resistance

a Do you think that antibiotic resistance existed in your hospital?
b Do you think that Antibiotic Resistance is an important and serious global public health issue?
c Have you ever felt that antibiotics prescribed by you would "likely" contribute to resistance?
d Do you think "Ineffective treatment can occur due to indiscriminate/ injudicious antimicrobial use"?
e Do you think "Antibiotic resistant could make medical procedures much more dangerous"?
f Do you think Bacteria resistant to antibiotics can be spread from one person to another?
g Antibiotic resistance occurs when your body becomes resistant to antibiotics no longer work
h Many infections are becoming increasingly resistant to treatment by antibiotics
i Antibiotic resistance is only an issue for people who take them frequently

Followed by which, they received an educational intervention based on the National Action Plan on Antimicrobial Resistance (NAP-AMR) Module for Prescribers 2024 by the National Medical Commission [8]. This intervention was delivered using a flipped classroom approach, where interns studied with materials like videos and readings on their own before attending interactive sessions and case discussions.

During the sessions, Principal Investigator and faculties observed interns performing clinical skills related to antimicrobial use such as taking patient histories, prescribing, and counselling using a Mini-CEX adapted from the NAP-AMR modules [8]. Immediate feedback was given to help improve skills. One week after the intervention post-test was conducted.

Data were analysed using SPSS version 23.0.

Descriptive statistics summarized socio-demographic characteristics and baseline data, while the pre- and post-intervention scores on the questionnaire and Mini-CEX assessments were compared using paired t-test or Wilcoxon signed-rank test.

RESULTS

In this quasi-experimental study, a total of 51 participants had responded. The participants mean (SD) age was 23.8 (1.096) and majority of them (58.82%) were female. Most of them (90.20%) had completed more than six months of their Internship Program and about 68.63% had not received prior training on antibiotic usage in their undergraduate period.

Analysis of pre- and post-test responses across the domains of knowledge, attitude, practice, and perception showed notable improvements following the educational intervention. In the knowledge and attitude domain, 70.59% of participants initially believed that antibiotics are safe drugs; this proportion increased significantly to 84.31% after the intervention ($p = 0.039$). The proportion of participants who reported that they routinely read standard treatment guidelines before prescribing antibiotics rose from 60.78% to 92.16% ($p < 0.001$). Awareness of the hospital's antibiotic guidelines improved from 52.94% at baseline to 86.27% post-intervention ($p < 0.001$) and those possessing a personal copy of these guidelines increased sharply from 9.8% to 52.94% ($p < 0.001$). Conversely, a decline in correct responses was observed for certain items, such as "whether prescribing inappropriate or unnecessary antibiotics is professionally unethical" and "whether empirical antibiotic management of all diseases is necessary to prevent Antimicrobial Resistance.

In the practice domain, around 84.31% of the participants in the pre-test responded that they save the remaining antibiotics for the next time when they get sick and it has been reduced to 80.39% in the post-test. About 41% of the participants (pre-test) responded that they discard the left over medication and it has been reduced to 35% in the post-test.

In the domain of perception, two-thirds (66.67%) of participants responded that bacterial resistant to antibiotics can spread from person to person in pre-test; while it increased to 86.27% in the post-test ($p = 0.021$). Nearly three-fourths (74.51%) of participants responded that antibiotic resistance occurs when the body becomes resistant to antibiotics and they no longer work. Following the intervention, it was improved significantly to 92.16% ($p = 0.012$). Also, the correct responses were decreased for questions such as, "Do you think antibiotic resistance exists in your hospital?" and "Do you think antibiotic resistance is a serious global public health issue?"

Before intervention more than half of participants (56.86%) were confident in adhering to the hospital's antibiotic policy, which significantly increased to 86.27% after the intervention ($p<0.001$) also, the confidence in choosing the correct antibiotic increased from 72.55% to 88.24% post intervention ($p = 0.021$). In planning the duration of antibiotic treatment, around 80.39% of participants had reported they were confident while it rose to 94.12% following the intervention ($p = 0.039$). Similarly, more than half (56.86%) of participants felt confident in using combination therapy before the intervention, which had increased to 86.27% after the intervention ($p=0.003$) and confidence in selecting the appropriate route of administration (intravenous, intramuscular or oral) increased from 82.35% to 96.08% ($p=0.016$). Around 70.59% of participants were confident in planning to streamline or discontinue antibiotic therapy based on clinical evaluation and investigations in the pre-test, which significantly increased to 94.12% in the post-test ($p = 0.003$). Following the intervention, decrease in the participant's confidence was not observed (Table 1).

Table 1: Confidence in prescribing antibiotics

Confidence in prescribing antibiotics	Pre-test		Post- test		p-value
	Confident n(%)	Unconfident n(%)	Confident n(%)	Unconfident n(%)	
Making an accurate diagnosis of infection	41(80.39)	10(19.61)	46(90.20)	5(9.80)	0.227
Adhering to hospital's antibiotic policy	29(56.86)	22(43.14)	44(86.27)	7(13.73)	<0.001*
Choosing the correct antibiotic	37(72.55)	14(27.45)	45(88.24)	6(11.76)	0.021*
Choosing correct dose and interval	41(80.39)	10(19.61)	47(92.16)	4(7.84)	0.146
Planning the duration of antibiotic course	41(80.39)	10(19.61)	48(94.12)	3(5.88)	0.039*
Using a combination therapy if appropriate	29(56.86)	22(43.14)	44(86.27)	7(13.73)	0.003*
Choosing the Route of administration	42(82.35)	9(17.65)	49(96.08)	2(3.92)	0.016*

Planning to streamline the treatment	36(70.59)	15(29.41)	47(92.16)	4(7.84)	0.003*
Interpreting microbiological results	44(86.27)	7(13.73)	48(94.12)	3(5.88)	0.289

* Significant at p<0.05 McNemar's test

Regarding the overall scores; knowledge and attitude domain increased from 8.039 ± 1.6848 in the pre-test to 9.529 ± 1.7012 in the post-test, showing a statistically significant improvement following the intervention ($p < 0.001$). However, the mean scores for practice reduced significantly, with values of 5.000 ± 1.2000 before the intervention and 4.922 ± 1.4120 afterwards ($p = 0.816$). Perception mean score rose from 7.078 ± 1.5079 in the pre-test to 7.588 ± 1.2834 in the post-test, which was statistically significant ($p = 0.014$). Confidence in prescribing antibiotics also showed a significant improvement, with the mean score increasing from 7.706 ± 3.7804 before the intervention to 10.804 ± 4.6820 after the intervention ($p < 0.001$) (Table 2).

Table 2: Comparison of overall mean (SD) Knowledge, attitude & practice, perception and level of confidence in prescribing antibiotics pre- and post-intervention among MBBS interns (n=51)

Domain	Time point	Number of items	Minimum	Maximum	Mean+ SD	p- value
Knowledge and Attitude	Pre-test	12	4	11	8.039+1.685	<0.001*
	Post-test		4	12	9.529 +1.701	
Practice	Pre-test	6	0	6	5.000+1.200	0.816
	Post-test		0	6	4.922+1.412	
Perception	Pre-test	9	2	9	7.078+1.508	0.014*
	Post-test		3	9	7.58+1.283	
Level of confidence	Pre-test	9	1	9	7.706+3.780	<0.001*
	Post-test		0	9	10.804+4.682	

* Significant at p<0.05 Paired sample T-test

Around 25 (49.0%) of the participants responded that overuse and inadequate use of antibiotics were found to be the major contributors of resistance, where only 9 (18%) said that poor hand hygiene as a contributing factor to resistance. Around 33 (64.71%) of the participants had reported that lack of time, lack of patient interest and concern that it will unsettle the patient were found to be barriers in discussing while prescribing antibiotics. Additionally, 12 participants (23.53%) reported that antibiotics are often inappropriately prescribed for upper respiratory tract infections and diarrhea in pre-test and for diarrhea 15 (29.41%) in post- test. (Figure 1, 2)

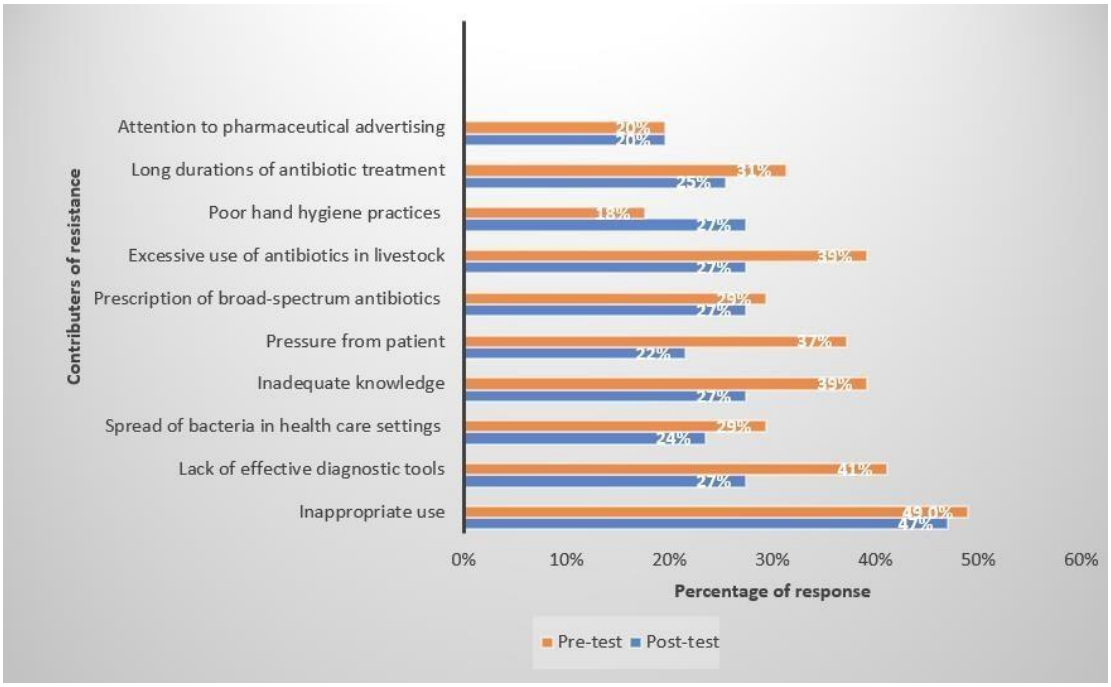

Figure 1: Contributors of resistance

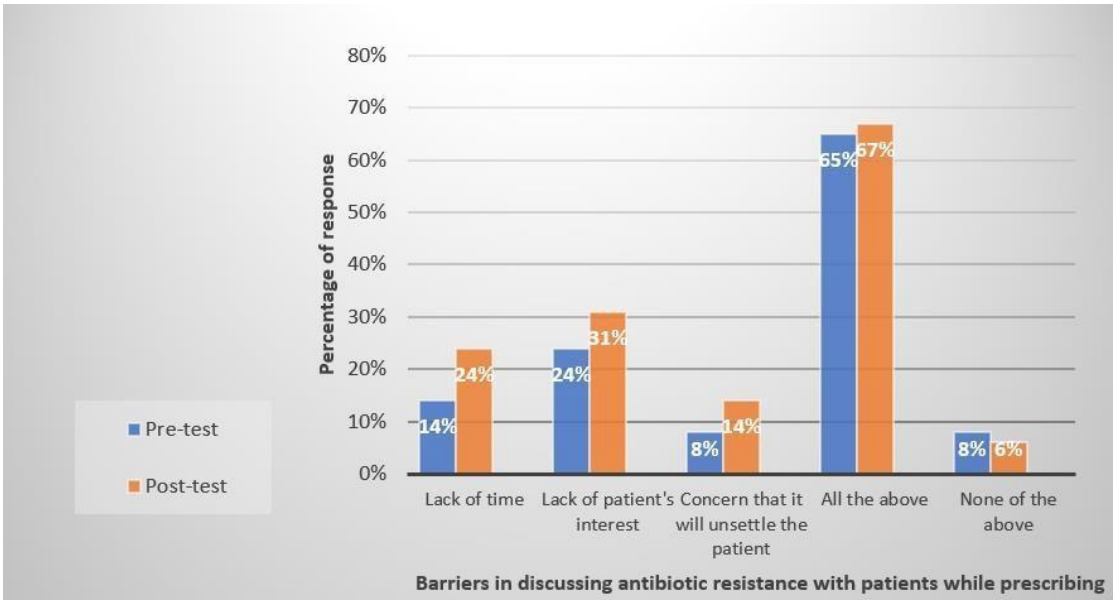

Figure 2: Barriers in discussing about antibiotic resistance with patients while prescribing

Following the intervention, feedback was obtained from the participants on the effectiveness of the session, engagement and satisfaction. Around 42(82.3%) responded that the intervention had helped them in understanding microbiological concepts of AMR and also helped them in planning the antibiotic course. Around 38(75%) had responded that the intervention and Mini-CEX had helped them in performing and counselling regarding AMR. Almost all of the participants said that the interventions were interesting and had kept them actively engaging. Majority of the interns 46(90.1%) had responded that this intervention methods can be used in other medical areas requiring clinical skills for enhancing their clinical competence.

DISCUSSION

This quasi-experimental study was conducted among 51 interns. The mean (SD) age of the participants was 23.80 (1.096) and majority 30 (58.82%) were female. Similarly in the study by Boban et al. the mean age (SD) of the participants was 21.91 (3.17), while in the study by Orok et al. the average age of participants was 17.8 (1.85) [9, 10]. Similarly in a study done by Dogra et al. majority of the participants were females 15 (71.42%) [11]. Studies were mainly done among UG and PG students the age group thus was comparable with other studies.

Regarding the knowledge and attitude about antibiotic usage, a statistically significant improvement was observed in post-test responses to several questions, such as "Are Antibiotics safe drugs to be used?" ($p = 0.039$), "Do you read standard treatment guidelines for antibiotic therapy before prescribing?" ($p < 0.001$), "Is there any guidelines for antibiotic followed in the hospital?" ($p < 0.001$) and "Have you got a copy of the hospital's antibiotic guidelines?" ($p < 0.001$). Contrastingly, in the study by Ramanarayanan et al. change in knowledge score was not significant, but participants responded correctly to the questions such as "Should dental infection always be treated with antibiotics?" (Pre-test: 39.5%, Post-test:79.1%) [12]. Also, for the question "Can antibiotics speed up the recovery process of cold and cough" shows statistical significance after intervention ($p = 0.017$). These variations may be due to individual variation in interpreting the result during assessment.

In practice domain, 84.31% had responded that they save the remaining antibiotics for using them the next time when they get sick. Whereas, only 80.39% had said they use this after the intervention. While 41% and 35% participants said that they discard the leftover medications in pre and post-tests respectively. Similarly, Ramanarayanan et al. reported that participants had the practice of consuming antibiotics based on the suggestions from friends/neighbours (pre-intervention: 95.3%) and there was decrease in such a practice after the intervention (83.7%) [12]. Reason for variations in practice may be due to the fact that the knowledge gained through the training will not always reflect in practice.

In the domain of perception, significant improvement in the participants' perception was seen after intervention such as; bacterial resistance to antibiotics can spread from person to person (Pre-test: 66.67% Post-test: 86.27%, $p = 0.021$), antibiotic resistance occurs when the body becomes resistant to antibiotics and they no longer work while there was a significant improvement following the intervention (Pre- test:74.51%, Post-test: 92.16%; $p = 0.012$). Similarly in the study by Thong et al. participants believed that they had a role to play in stopping antibiotic resistance before the intervention (pre-test:26.5%, Post-test after 2 weeks of intervention:69.2%, $p<0.001$) and concern

about the antibiotic resistance impact on their health and family (Pre: 66.2%; Post-test after 2 weeks of intervention: 86.8%; p < 0.001) [13]. The improvement in the perception could be attributed to due to knowledge improvement post intervention.

Following the intervention, Confidence of the participants improved significantly as follows; in adhering to the hospital's antibiotic policy (Pre-test: 56.86%, Post-test:86.27%, p < 0.001), choosing the correct antibiotic increased from (Pre-test:72.55%, Post-test:88.24%, p = 0.021), planning the duration of antibiotic treatment (Pre-test:80.39%, Post-test:94.12%, p = 0.039), choosing appropriate combination therapy (Pre-test: 56.86%, Post-test:86.27%, p = 0.003). Similar improvement was reported by Malli et al. in prescribing combination therapy (Pre-test:12%, Post-test:36.4%) [14]. In the present study, selecting the appropriate route of administration (intravenous, intramuscular or oral) (Pre-test:82.35%, Post-test:96.08%, p = 0.016), planning to streamline or discontinue antibiotic therapy based on clinical evaluation (Pre-test:70.59%, Post-test: 94.12%, p = 0.003). Similarly study by Malli et al. around 30.3% of the participants reported that they were confident in prescribing an Antibiotic accurately while diagnosing an infection that needs antibacterial treatment followed by 66.7% in the post- test [14]. Improvement in the confidence among the participants could be attributed to the employment of mini-CEX as a method of health intervention.

In the present study, after the educational intervention overall knowledge and attitude domain was found to be statistically significant (p <0.001) whereas no significance was noted in practice (0.816). Similarly, in study by Boban et al. after the intervention, the participants' knowledge had improved significantly (p < 0.001) [9]. On contrast, study done by Ramanarayanan et al. where educational module improved the attitudes regarding AMR but did not significantly improve knowledge and practice [12]. The significant improvement in the knowledge could be due to effectiveness of the intervention given. The reason for decrease in the overall mean score of practice indicates that the knowledge gained through the training will not always reflect in practice. In this study, perception domain was found to be statistically significant (p = 0.014). In contrast, study done by Saleh et al. no significant changes were reported in their response after the workshop towards perception on antimicrobial stewardship programs (p>0.05) [15]. Highlighting the ethical and professional role of healthcare providers in rational antibiotic use may have positively shaped perceptions. In the current study, confidence in prescribing antibiotics showed a significant improvement after the intervention (p < 0.001), similarly in a study done by Malli et al. antibiotic stewardship course revealed a significant difference in students' confidence before and after enrolling in the online educational program (p < 0.002) [14]. This could be because the session based on recent national AMR guidelines would have improved their confidence in prescribing antibiotics.

CONCLUSION

A targeted FC and Mini-CEX–based educational intervention significantly improved interns' knowledge, attitude, perception and prescribing confidence related to antimicrobics. A statistically significant improvement was observed in adhering to the guidelines while prescribing, optimising and de-escalation of therapy but self-reported practices were minimal. In order to address this concern and change the behaviour in the prescription pattern, such active learning strategies can be integrated into clinical training protocol.

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ETHICS APPROVAL

This study was approved by the Institutional Ethical Committee of Sri Venkateshwaraa Medical College Hospital and Research Centre [Ref no:09/SVMCH/IEC-Cert/Mar.25].

CONFLICT OF INTEREST

The authors have declared that there is no conflict of interest.

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