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The impact of antibiotic resistance training programs on knowledge, attitude, and practice reflection among Indian higher education students

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Abstract

Background: Antibiotic resistance (ABR) is one of the most pressing public health issues. Resistant pathogens originate from antibiotic misuse and unsustainable socioeconomic patterns. Co-financed by the European Commission, the Erasmus + capacity building project, PREVENT IT | Risk Management and Prevention of ABR, aims to improve the effectiveness of the study programs of Indian universities vis-à-vis ABR. This study aimed to evaluate the impact of the ABR training programs on the knowledge, attitude, and practice (KAP) reflection of undergraduate and postgraduate students from five Indian universities.

Materials and Methods: In this multicentric study, the KAP reflection of the students was assessed before (pre) and after (post) the intervention of experiential ABR training. Paired t-test and one-way analysis of variance were used to analyze the impact of intervention using the Statistical Package for the Social Sciences software.

Results: A total of 515 students participated in the study. The findings indicate a significant improvement in the knowledge and attitude scores, while a minor change was observed in practice reflection.

Conclusion: The intervention conducted within the framework of the project could set a good practice for the prevention and risk management of antibiotic-resistant bacteria.

Keywords: health, antibiotic resistance, training, innovations and health, attitude and practice, capacity building, equal access, awareness, increasing life expectancy, international health policy.

Introduction

Every year, resistant bacteria kill over 700,000 people, and ABR is expected to become the first cause of death by 2050 [1]. Microbes can mutate quickly, increasing the chance of developing mechanisms that nullify the efficacy of available drugs. These transformations allow microbes to inactivate or efflux drugs. Due to the misuse of antibiotics, bacteria began to transfer genes horizontally to other microbes. The spread of multidrug-resistant bacteria such as methicillin-resistant - *Staphylococcus aureus*, vancomycin-resistant *Enterococci*, and carbapenem-resistant *Enterococci* has become a significant problem in all intensive care settings [2]. Despite the launch of global and national initiatives designed to address this issue, ABR remains an ill-structured problem. It has global consequences, causing significant clinical, social, and economic losses [3, 4]. Antibiotic resistance (ABR) is exacerbated by inaccurate antibiotic prescriptions, patient misuse, and overuse in the food chain [5]. As the first step to limit the development of new resistant bacteria, healthcare professionals must ensure the judicious use of antimicrobial drugs, identify the causative organisms, and prescribe the appropriate pharmacological therapies.

Acknowledging the alarming state of the art, the World Health Assembly adopted the antimicrobial resistance (AMR) global action plan in 2015 [6]. The plan includes a set of interconnected measures aimed at (i) raising awareness through effective communication, education, and training; (ii) strengthening surveillance and research; (iii) improving sanitation and infection prevention measures; (iv) optimizing the use of antimicrobial medications; and (v) investing financial resources in new medicines, vaccines, and diagnostic tools. The adoption of a global strategy requires the enactment of national initiatives. From a sociopolitical perspective, implementing policies at the local level plays a central role in curbing the ABR fatality rate [7]. Following this rationale, every state agreed to adopt (and implement) a national action plan (NAP) to tackle the spread of resistant pathogens. Adapting the global goals to domestic realities, the Indian Ministry of Health and Family Welfare released the NAP to Combat AMR in 2017. Based on a 5-year action plan (2017–2021), the NAP outlines strategies for combating AMR, operationalizing the roadmap approved by the World Health Assembly for the Indian scenario [7].

Tackling AMR in India would significantly improve the country's sanitary, economic, and social performance [4]. Even though the different areas of intervention covered by the global and Indian plans [7–9] are critical and self-reinforcing, education acquires a pivotal position in tackling ABR at its root. Multiple studies have shown that Indian students are unaware of ABR [10–12]. Therefore, the development of educational initiatives addressing prescription practices, infection control, and prevention is indispensable elements of any strategy aiming to minimize AMR. Education is the key to inducing behavioral changes, even when the effectiveness of these initiatives is influenced by pre-existing beliefs [13]. In India, the causes of irrational or inappropriate antibiotic consumption have been associated with lack of knowledge, attitude, and practice (KAP) among physicians [10]. Numerous studies have demonstrated that training campaigns can foster antibiotic stewardship [14]. Improving student learning outputs can significantly improve individual behaviors and enhance the impact of the higher education sector on health development. Nonetheless, educational interventions should be calibrated to the local culture to be impactful over time. Learning activities should target every discipline connected with the emergence of resistant pathogens to create interdisciplinary synergies. To achieve this goal, higher education curricula must be transversally modified to include risk management and AMR/ABR prevention content in the highest number of study programs. From stsate-of-the-art observation, Indian schools and universities have not been covered by ABR-awareness campaigns. In addition, ABR training activities should not be limited to the outreach of students. Investments should be allocated to develop awareness campaigns that educate society about the causes and consequences of drug resistance [15]. This investment could improve societal attitudes toward antibiotic consumption, especially in India, where most of the population is young.

Responding to the observed challenges, the PREVENT IT (ERASMUS plus funded) project aims to increase AMR-related skills among Indian higher education students, promoting an array of learning activities engaging a differentiated target group. The aim of the project was to improve the societal attitude toward the use of antibiotics, implementing a set of initiatives targeting future Indian professionals. An interdisciplinary team of professionals from 11 organizations, including four European universities, five Indian higher education institutions, and two non-governmental organizations has collaborated to implement the project. The experiential teaching activities targeted both academic and societal players [16].

The project produced behavioral modifications through the dissemination of information on antibiotic use. It has modernized higher education study programs and spread awareness, developing a dissemination strategy blending traditional academic activities with digital campaigning. Before operationalizing the intervention, the project team tailored the learning materials to the beliefs and perceptions of the target groups. Higher education students were considered the most receptive audience. They spend nearly 8 h/day on the premises of their institution, interacting with their peers and teachers. Education can profoundly impact their behavioral patterns, providing an opportunity to create a societal spillover that facilitates the prevention and risk management of ABR.

This study aimed to evaluate the impact of the ABR training programs on the KAP reflection of undergraduate and postgraduate students from five Indian universities.

Materials and Methods

Ethical approval

The respective Institution's Ethics Committee approved the conduct of the pre- and post-training assessments.

Study period and design

The study was conducted from September 2020 to January 2022. This study was based onpre- andd post-analysis evaluations of the impact of the experiential educational activities developed within the project framework. The pre-and post-intervention study was conducted to measure the change in KAP reflection of Indian higher education students who had undergone experiential AMR/ABR training. Depending on the start and end dates of the training, the pre-assessment was conducted from September 2020 to November 2021, while the post-assessment was performed from October 2020 to January 2022. The study was designed to understand the effectiveness of the curricula intervention in enhancing the knowledge, attitude, and practice reflection toward ABR. The term antibiotic is commonly used and understood among Indian higher education students. For this reason, antibiotics and ABR were extensively deployed in the questionnaire. Furthermore, rather than on drugs deployed to treat viral, parasitic, and fungal diseases, our focus was primarily on antibiotics commonly used in the community to treat bacterial infections.

Study setting and study population

A multicentric study involved the students enrolled in five Indian higher education institutions based in different Indian states (Kerala, Punjab, Odisha, Karnataka, and Maharashtra) offering diverse academic programs. The details of the programs are shown in Table-1.

Selection of participants

The students enrolled in study programs were from the ABR experiential training program.

Exclusion criteria

The students who requested to be excluded from the study and those enrolled in study programs not covered by the PREVENT IT project were excluded from the study.

Sample size

In the multicentric study, the students from the study programs mentioned in Table-1 were included in the assessment through the census method. In total, 515 students participated in the study.

Development of questionnaire

A context-specific tool was designed through a consultative process to assess the KAP reflection of the target group. The questionnaire was designed around the research aim and was adapted to the target group. The draft questionnaire was reviewed by an expert group of public health professionals, microbiologists, physicians, ayurveda, yoga and naturopathy, Unani, Siddha, and homeopathy practitioners. An interviewer's manual was prepared with detailed instructions. A pilot study was conducted among 128 students to test the comprehensibility, relevance, acceptability, and feasibility of the questions. The feedback received has been instrumental in consolidating the questionnaire.

In total, the semi-structured questionnaire consisted of 52 questions. The questionnaire had five sections: demographic information, perspective toward ABR, and KAP reflection. There were 25 questions to assess the knowledge level of the participants, ten questions to identify the attitude, and four questions to evaluate the practice reflection of the participants. The questionnaire was administered electronically using Google Forms before and after the curricula were delivered to the students.

Assessing KAP reflection domains

The scoring for each domain was given according to the following criteria:

Knowledge domain

The scoring was based on 25 questions evaluating the knowledge level of the participants. The questions were related to antibiotics, ABR, and various strategies to prevent and control ABR. Each correct answer scored 1, while the wrong answer scored 0. The maximum score from this section was 25.

Attitude domain

The scoring was based on ten questions assessing the attitude of the respondents. A 4-point Likert scale was used. The responses were scored as equivalent to 1, 2, 3, and 4, where 1 corresponds to the most negative attitude, and 4 represents the positive end of the spectrum. The score from this section was 40.

Practice reflection domain

There were four questions to assess the practice reflection. A 4-point Likert scale was applied to three questions using the same coding criteria adopted to scale the attitude domain. The remaining question was coded as equivalent to 0 for unacceptable practice and 1 for acceptable practice. The maximum score obtainable in this section was 13.

Statistical analysis

The responses from Google Forms were exported into Microsoft Excel for data cleaning. The database was transferred to the Statistical Package for the Social Sciences version 27.0 (IBM Corp., NY, USA) for coding and analysis. Data from continuous variables are presented as mean ± standard deviation, while categorical variables are presented as percentages. A descriptive analysis was conducted. The participants were categorized into six groups based on their study programs for disaggregated analysis.

Table-1: Geographical distribution of the higher education institutions involved in the study and details of the programs outreached.

Higher education institutions and location	Academic programs outreached
Amrita Vishwa Vidyapeetham (Kochi, Kerala)	Bachelor of Medicine and Surgery (MBBS), Bachelor of Dental Surgery, Bachelor of Pharmacy, Master of Pharmacy, Doctor of Pharmacy, Bachelor of Nursing, Bachelor of Allied Health Sciences
Chitkara University, Punjab (Rajpura, Punjab)	Bachelor of Optometry, Bachelor of Physiotherapy, Bachelor of Occupational Therapy, Bachelor of Allied Health Sciences, Master of Allied Health Sciences, Master of Healthcare Management (MBA Healthcare), Master of Optometry
Kalinga Institute of Industrial Technology deemed to be University (Bhubaneswar, Odisha)	MPH, PhD in Public Health, MHA, Bachelor of Nursing, Master of Nursing
Manipal Academy of Higher Education (Udupi, Karnataka)	MPH
Symbiosis International deemed University (Pune, Maharashtra)	Master in Biotechnology, Master in Nutrition and Dietetics

MBBS=Bachelor of Medicine and Bachelor of Surgery, MBA=Master of Business Administration, MPH=Master of Public Health, MHA=Master of Hospital Administration

A paired sample t-test was used to identify the intervention's impact within a group. One-way analysis of variance (ANOVA) was employed to detect whether the groups differed significantly. If it was significant, a *post hoc* Bonferroni test was performed to determine which groups differed significantly. The significance value was set at $p < 0.05$.

Demographic data

In total, the study collected 1030 responses from 515 students. The mean age of the participants was 21.9 ± 3.17 years. Participants were mostly female (84.7%). More than half of the participants were undergraduate students. Most respondents were enrolled in the academic programs of Allied Health Sciences (27%) and Pharmacy (21.6%).

Results

Out of 515 respondents, 97.7% (503) of students have taken antibiotics during their life, mainly following fever (80.7%) and flu symptoms (48.1%). In the target group, 97.1% (500) had heard about ABR before the experiential learning activities. However, only 32.4% (167) of the students were familiar with terms such as superbugs, bacterial resistance, and drug resistance (Table-2). Most participants have received basic information on ABR from teachers and literature. In contrast, few respondents were informed by healthcare professionals, workshops, awareness campaigns, and social media.

Impact of ABR training on KAP reflection scores among students

The mean KAP reflection scores before and after intervention across various groups is shown in Table-3. Before the experiential learning activities, the score related to the knowledge of the Indian higher education students ranged from 2 to 24 with a mean of 15.46 ± 3.78. Following the project intervention, the knowledge of the target group significantly improved ($p < 0.001$, 17.25 ± 4.26). Similar progress was observed in the attitude of the students. After the intervention, the score increased from a mean of 32.57 ± 4.37 to 34.13 ± 4.64 ($p < 0.001$). Nonetheless, the experiential learning activities had a marginal impact on the practice reflections (pre-intervention 9.4 ± 2.22, post-intervention 9.48 ± 2.32, $p = 0.339$).

As shown in Table-4, except for the medical and dental students, the improvement in knowledge scores was highly significant across all groups. Knowledge enhancement was observed among the MPH, MHA, and MBA students, followed by the Allied Health

Table-2: Demographic information and students' perspective on ABR.

Variables	n	%
Gender		
Male	79	15.1
Female	436	84.7
Type of program		
Bachelors	291	56.5
Masters	224	43.5
Age (mean and SD)	21.91 ± 3.17 (17–49)	
Program		
Medical and dental	68	13.2
Nursing	75	14.6
Pharmacy	111	21.6
Allied Health Sciences	139	27
Microbiology and Biotechnology	45	8.7
MPH, MBA healthcare, and MHA	77	15
Ever heard of the terms		
ABR	462	89.7
Superbugs	189	36.7
Bacterial resistance against antibiotics	387	75.1
Drug resistance	422	81.9
None	15	2.9
Information source		
Books/journals	386	77.2
Teachers	398	79.6
Healthcare workers	254	50.8
Workshops/seminars/lectures	271	54.2
Media	244	48.8
Awareness campaigns	140	28.0
Others	4	0.78
Conditions for which antibiotics were consumed		
Common cold	242	48.1
Diarrhea	137	27.2
Surgical procedures	158	31.4
Fever	406	80.7
Headache	114	22.7
Others (sore throat, acne, dental treatment, pain, and allergy)	21	4.2

ABR=Antibiotic resistance, SD=Standard deviation, MBA=Master of Business Administration, MPH=Master of Public Health, MHA=Master of Hospital Administration

Sciences students. However, the one-way ANOVA analysis showed that the performance in terms of knowledge significantly differs among the groups. Bonferroni *post hoc* test revealed that the improvement in knowledge among MPH, MHA, and MBA health-care students and Allied Health Sciences students was significantly superior (p = 0.001) compared to the medical, dental, and nursing groups. Similarly, the Allied Health Sciences group showed a consistent improvement in knowledge compared to pharmacy students (p = 0.035).

As shown in Table-5, the improvement in attitude was significant across pharmacy, Allied Health Sciences, and MPH, MHA, and MBA health-care students. Even in this case, the change in attitude significantly differed between groups. The Bonferroni *post hoc* test identified that the variation in attitude scores in Allied Health Sciences group significantly differed from all other groups. Hence, the progress was higher for the Allied Health Sciences students, followed by the MPH, MHA, and MBA healthcare groups.

As shown in Table-6, the practice reflection scores did not show any significant difference, even when compared within (and between) the groups.

Discussion

Antibiotic misuse in human and animal health has generated a silent pandemic. Resistant pathogens created an unsustainable scenario where it is imperative to lower the incidence of ABR [5]. The existing global and NAPs focus on six areas of intervention: Education and awareness, surveillance, infection prevention, antibiotic-optimized use, leadership, and research and innovation. Among these areas, education is the instrument acting at the root level, shaping leaders, developing new standards for surveillance, designing policies that optimize the use of antibiotics, and discovering compounds to defeat resistant

Table-3: Mean KAP scores across various groups before and after the intervention.

Students pursuing the following programs	n	Mean (SD)					
		Knowledge		Attitude		Practice	
		Pre score	Post score	Pre score	Post score	Pre score	Post score
Medical and Dental	68	17.37 (3.65)	17.88 (3.77)	33.40 (4.07)	34.07 (4.40)	9.66 (2.16)	9.68 (2.38)
Nursing	75	13.00 (3.80)	13.55 (4.79)	31.21 (5.09)	32.01 (5.13)	8.75 (2.27)	8.79 (2.56)
Pharmacy	111	16.53 (3.61)	17.94 (4.07)	33.94 (4.40)	34.80 (4.17)	9.85 (2.22)	10.11 (2.23)
Allied Health Sciences	139	14.77 (3.09)	17.47 (3.56)	31.65 (4.02)	34.55 (4.22)	9.27 (2.20)	9.28 (2.14)
Microbiology and Biotechnology	45	15.67 (4.12)	18.02 (4.28)	32.93 (4.06)	33.42 (5.09)	8.71 (1.77)	8.84 (2.04)
MPH, MHA, MBA Healthcare	77	15.75 (3.61)	18.49 (3.67)	32.64 (3.92)	34.95 (4.90)	9.78 (2.33)	9.79 (2.36)
Total	515	15.46 (3.78)	17.25 (4.26)	32.57 (4.37)	34.13 (4.64)	9.40 (2.23)	9.48 (2.32)

KAP=Knowledge, attitude, and practice, SD=Standard deviation, MBA=Master of Business Administration, MPH=Master of Public Health, MHA=Master of Hospital Administration

Table-4: Change in knowledge scores across groups.

Students	Knowledge score		p-value	
	Pre (mean, SD)	Post (mean, SD)	Within group	Between groups
Medical and Dental	17.37 (3.65)	17.88 (3.77)	0.143	0.000
Nursing	13 (3.799)	13.55 (4.79)	0.137	
Pharmacy	16.53 (3.61)	17.94 (4.07)	0.000	
Allied Health Sciences	14.77 (3.09)	17.47 (3.56)	0.000	
Microbiology and Biotechnology	15.67 (4.12)	18.02 (4.28)	0.000	
MPH, MHA, MBA Healthcare	15.75 (3.61)	18.49 (3.67)	0.000	
Total	15.46 (3.78)	17.25 (4.26)	0.000	

SD=Standard deviation, MBA=Master of Business Administration, MPH=Master of Public Health, MHA=Master of Hospital Administration

Table-5: Change in attitude scores across groups.

Students	Attitude score		p-value	
	Pre (mean, SD)	Post (mean, SD)	Within group	Between groups
Medical and dental	33.397 (4.07)	34.07 (4.40)	0.157	0.000
Nursing	31.21 (5.09)	32.01 (5.13)	0.089	
Pharmacy	33.94 (4.396)	34.8 (4.17)	0.022	
Allied Health Sciences	31.65 (4.02)	34.55 (4.22)	0.000	
Microbiology and biotechnology	32.93 (4.06)	33.42 (5.09)	0.551	
MPH, MHA, and MBA healthcare	32.64 (3.92)	34.95 (4.9)	0.000	
Total	32.57 (4.37)	34.13 (4.64)	0.000	

SD=Standard deviation, MBA=Master of Business Administration, MPH=Master of Public Health, MHA=Master of Hospital Administration

Table-6: Change in practice reflection scores across groups.

Students	Practice reflection score		p-value	
	Pre (mean, SD)	Post (mean, SD)	Within group	Between groups
Medical and Dental	9.66 (2.16)	9.68 (2.38)	0.961	0.928
Nursing	8.75 (2.27)	8.79 (2.56)	0.832	
Pharmacy	9.85 (2.22)	10.11 (2.23)	0.137	
Allied Health Sciences	9.27 (2.195)	9.28 (2.14)	0.937	
Microbiology and Biotechnology	8.71 (1.77)	8.84 (2.04)	0.503	
MPH, MHA, and MBA Healthcare	9.78 (2.33)	9.79 (2.36)	0.947	
Total	9.396 (2.23)	9.48 (2.32)	0.339	

SD=Standard deviation, MBA=Master of Business Administration, MPH=Master of Public Health, MHA=Master of Hospital Administration

pathogens. Ensuring adequate AMR training for the students can significantly change the behavior of the new generations. To achieve this goal, the PREVENT IT project developed initiatives to create skills and awareness among Indian higher education students. This aim was pursued by incorporating risk management and prevention content in the existing academic courses.

In the framework of this research, a study protocol was designed to assess the effectiveness of the experiential training activities on the KAP reflections of the outreached Indian higher education students. It was found that most students have insufficient awareness and knowledge regarding the impact of resistant pathogens. The primary source of information on AMR/ABR was the education sector, with a minor contribution from the media and healthcare workers. This finding contradicts a cluster of studies in which the primary source of information was the Internet [17, 18]. Reflecting the conclusion of an earlier investigation conducted in India [19], a remarkable percentage of students used antibiotics after minor symptoms appeared. Overall, the training conducted within the framework of the project had the intended impact on the target group. The mean knowledge from the post-test (17.25) was higher than the pre-test (15.46). The maximum increase was observed among the healthcare management, microbiology, biotechnology, and Allied Health Sciences cohorts. A minor impact has been observed on the knowledge of the medical, nursing, and pharmacy students. This can be explained by the pre-existent knowledge detected in these groups during the pre-assessment study. Therefore, these findings confirm the earlier reports highlighting the better preparedness of medical and pharmacy students [14, 20–22].

The results prove that all the programs involved in the experimentation have benefited from modernizing the academic curricula. The impact of the experiential activities was very significant in the Allied Health Sciences, MPH, MHA, and MBA cohorts. Irrespective of the study program enrolled, every student showed an improvement in attitude toward inappropriate antibiotic prescriptions, premature interruption of antibiotic therapy, and diagnostics practices. Furthermore, the experiential learning activities improved the students' awareness of AMR's societal and sanitary impact. Similar to the conclusion of another study performed in India [12], the improvement in the attitude of medical students was higher than that of the students enrolled in nursing programs. However, it has not been observed the deep attitudinal gap highlighted in a study conducted in Nepal [22]. In line with a study from East Africa [23], the research demonstrated that Indian pharmacy students displayed a better attitude than their medical peers.

Finally, it is questionable whether the observed rising level of knowledge among the medical students and in the other groups scrutinized was translated into improving attitudes and practice reflections among future Indian health professionals. The previous studies by Sharma *et al*. [24], Khan *et al*. [25], and Rajiah *et al*. [26] have raised similar perplexities. Confirming this concern, after the exposure to the experiential learning activities, the scores from practice reflection did not show significant improvement across the groups. This can be partially explained by time and experiential factors. Although the groups showed a substantial increase in knowledge, translating those skills into practice takes time and requires constant reinforcement through professional practice and lifelong education. It can be concluded that activities designed to induce behavioral change targeting Indian professionals should be implemented to bridge the gap between theory and practice.

Strengths and limitations

This study was conducted within the framework of a project implemented by an Indian-European alliance, united by the common purpose of enriching Indian academic curricula with ABR-related content. To the best of our knowledge, this is the first multicentric study conducted across various programs in different universities in India, including students from different regions. The novelty, the large sample size, and the short follow-up period that minimized the dropout rate represent an important strength of this study.

Our study has some limitations. The study was conducted without a control group. Hence, the progress observed among Indian higher education students could also be associated with other ABR-awareness initiatives. We used online questionnaires with closed-ended questions, which could have affected the KAP scores. Similarly, monitoring the students while answering the questions was impossible because the questionnaires were administered online. Finally, the questionnaire was time-demanding, which could have decreased the concentration and/or interest among the study groups.

Conclusion

This study assessed the impact of experiential teaching activities promoting good practices in ABR prevention and risk management. Our study concluded that the teaching activities significantly improved the knowledge and attitude of the Indian students. For this reason, it is necessary to promote a reform of the academic curricula, generating adequate awareness and interest in AMR among the Indian youth. As far as practice reflection is concerned, new experiential initiatives are required to improve individual behaviors. It can be suggested that Indian educational institutions should be engaged in promoting and disseminating the One Health paradigm. Considering the ill-structured nature of AMR, professionals from non-medical sciences should be trained and engaged in the fight against resistant pathogens. Furthermore, because ABR is a global issue, there is a pressing need to coordinate the actions and the programs developed in different countries, sharing best practices, pooling financial resources, and adapting the learning materials to the local culture and beliefs.

Authors' Contributions

DB, KK, SG, and HSP: Contributed to the conception, design, implementation, and analysis and interpretation of the data. RJ, KR, and JP: Assisted in the data collection and drafting and revision of the manuscript. All authors have read, reviewed, and approved the final manuscript.

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Competing Interests

The authors declare that they have no competing interests.

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