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Development and Assessment of Awareness Module on 'Antimicrobial Resistance and its Prevention' for School Students in Punjab, India

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Abstract

Antimicrobial resistance (AMR) is one of the pressing public health issues. Sharing information on AMR with school students will educate and inspire them to act as community ambassadors. The present study was carried out in the form of capacity-building workshops among school children of the Ludhiana district of Punjab, India. Three workshops were organized in three different higher secondary schools for 11th and 12th standard students (medical stream). Each workshop session included an interactive teaching module on basic microbiology, AMR, factors involved in AMR emergence, 'One Health' approach to address AMR, and how we can contribute to the community. The learning outcomes were evaluated based on pre and post-workshop assessment questionnaires. A total of 138 students participated in the workshops with an average duration of around 3.5 hours. Among all the students, 68.84% were not aware of the meaning of 'antibiotic resistance' and 78.26% believed that antibiotics can cure all coughs and colds. Furthermore, 82.61% of students never heard the term 'superbugs' and 71.74% were not able to identify the factors for AMR emergence. The success of teaching workshops was assessed by significant improvement in the correct responses during the post-workshop quiz, where the median post-workshop score (i.e., 14/15) was significantly improved as compared to the pre-workshop score (i.e., 08/15). We propose that the concepts of AMR must be included in school curricula so that young students can be 'superheroes' in bringing about desired changes in the community.

Keywords: *Antimicrobial resistance, awareness, one health, public health, school students*

Antimicrobials are considered one of the most significant discoveries in medical science to fight against infectious diseases in humans as well as animals (Seal *et al.,* 2013). Microbial resistance to antimicrobial agents is a widespread occurrence in both community and healthcare

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settings, referred to as 'antimicrobial resistance'. This phenomenon poses a substantial threat to our healthcare systems. A recent study reported the bacterial AMR was directly responsible for an estimated 1.27 million deaths worldwide, and associated with an estimated 4.95 million deaths, in 2019 (Murray *et al.,* 2022).

AMR is a multifaceted issue influenced by biological, social, behavioural, and economic factors (Malik and Bhattacharyya, 2019; Vijay *et al.,* 2022). Non-judicious drug usage in human and animal sectors drives microbial selection pressure, leading to resistance. Resource-limited settings exacerbate this problem due to low infection prevention and control (IPC) measures, self-medication, prescription sharing, over-the-counter antimicrobial sales, non-compliance with treatment schedules, limited diagnostics and surveillance, and weak stewardship (Tompson *et al*., 2021).

In 2015, the World Health Assembly adopted a 'global action plan on antimicrobial resistance' with five main objectives. The first objective of this action plan is to improve awareness and understanding of antimicrobial resistance through effective communication, education and training, which strongly advocates the role of effective public awareness about the challenges of AMR (WHO, 2015). As per estimates, India has the highest consumption of antibiotics among the countries studied (Van Boeckel *et al.,* 2014). Between 2000 and 2015, antibiotic consumption in India was estimated to be increased by 103%, that is, from 3.2 to 6.5 billion defined daily doses (DDDs) (Klein *et al.,* 2018). This rise in antimicrobial consumption along with other socio-cultural and economic factors like availability of over-the-counter medicine, the attitude toward self-medication, non-availability or non-utilization of diagnostic services, ethical challenges among healthcare professionals, low doctors/nurses' ratio relative to the population, unethical commercial promotion of the sale of antibiotics, and regulatory issues, raise the concern about this complex public health challenge. Apart from this, the indiscriminate usage of antibiotics in animal husbandry practices (Vijay *et al.*, 2021; Dhaka *et al.,* 2023) and the environmental concerns related to the pharmaceutical waste waters and hospital effluents make this an issue to be addressed in the 'One Health' framework (Taneja and Sharma, 2019).

India's National Action Plan (NAP) for AMR was launched in 2017 by the Union Ministry of Health and Family Welfare. In line with World Health Organization's (WHO) 'global action plan on antimicrobial resistance', the objectives of the NAP include improving awareness, enhancing surveillance measures, strengthening IPC, research and development, promoting investments, and collaborative activities to control AMR (Ranjalkar and Chandy, 2019). The national plan also emphasised community awareness as an important tool to fight against AMR.

As AMR is also a social issue driven by human behaviour and practices, and thus community engagement remains a bottom-up approach to tackle it (Mitchell *et al.,* 2022). In developing nations, the benefits of such community engagement can address the complex AMR-related inequalities. Previous interventions targeting school children have shown sustained improvements in knowledge, attitudes, and practices regarding responsible antibiotic use (Aboalshamat *et al.,* 2019; Fernandes *et al.,* 2019; Appiah *et al.,* 2022). There are limited studies on public awareness of AMR issues in India, particularly among school children. With this background, the present study was carried out in the form of capacity-building workshops to assess the effectiveness of the developed teaching modules in influencing the knowledge, attitudes, and beliefs of school children in the Ludhiana district of Punjab, India.

Material and methods

Study area and duration

As part of the 'Superheroes Against Superbugs Fellowship', three workshop sessions were organised for 11th and 12th students in the medical stream in three different schools of the Ludhiana district of Punjab from March, 2022 to June, 2022. The project was supported by Superheroes Against Superbugs and LV Prasad Eye Institute, Hyderabad.

Selection of study participants

A total of three workshops were conducted in public (n=1) and private (n=2) schools in the Ludhiana district of Punjab. The workshop schedule and timings were finalised with the consent of the teachers of the respective classes. Student participation was entirely voluntary, and the workshops were conducted during regular school hours. The students were explained the objectives of the workshop and proper verbal consent was taken for their volunteer participation.

Development of an educational module for the workshop

Each workshop session included an interactive teaching module in the form of Microsoft PowerPoint 2019 (Microsoft Corp., Santa Rosa, CA) with graphics and short videos. The teaching module included the following 08 discussion points:

1. What are microbes? Are they our 'friends' or 'foe'?
2. What are 'antimicrobials' and 'antibiotics'?
3. A brief history of antibiotics: discovery and their use as a 'miracle drugs'
4. What is antimicrobial resistance (AMR)?, and AMR mechanisms
5. Know about the factors governing AMR: Need for 'One Health'approach
6. What can we do as a community?
7. Take away messages!
8. Let's pledge 'to be a Superhero' of the AMR awareness campaign

Pre and post-workshop assessment

The learning outcomes of the module were evaluated based on pre and post-workshop assessment questionnaires shared with the students. The pre and post-workshop assessment quizzes were based on 15 questions which were designed by discussions with the academicians of Guru Angad Dev Veterinary and Animal Sciences University and science communicators from 'Superheroes Against Superbugs' platform. The questions along with their expected answers are provided in Table 1. The full questionnaire has been provided as Supplementary draft 1.

Workshop schedule

The entire workshop session was designed for an average of 03 hours duration in the classroom provided with a pre-workshop quiz (15-20 min) followed by exposure to an educational lecture (2 h), discussion with students (30-45 min) and a post-workshop quiz (15-20 min). The educational lecture session included a structured course module, brief AMR awareness videos, demonstrations involving cultured Petri plates containing commensal *Escherichia coli* bacteria and antibiotic sensitivity testing, as well as practical demonstrations using both a paracetamol strip and an amoxicillin strip to illustrate the differences. After the lecture, the discussion was carried out to further clarify the concepts and queries on AMR. The workshop session was concluded with a post-workshop assessment quiz with the same questionnaire that was used during the pre-workshop assessment.

Statistical analysis

The marked pre and post-workshop assessment quiz responses were manually evaluated. Each correct response was given a point and the overall percentage scores were calculated for all participants. All the calculations were carried out by using Microsoft® Office Excel 2019 (Microsoft Corp., Santa Rosa, CA). The Wilcoxon Signed-Ranks test was used to analyze the pre and post-workshop assessment quiz responses of students. A p-value of ≤0.05 was interpreted as significant.

Results and discussion

A total of 138 school students [school 1 (n=34), school 2 (n=51), and school 3 (n=53)] of 11th and 12th (medical stream) along with their teachers (n=12) voluntarily participated in the workshops. Overall, 72 (52.17%) were girls and 66 (47.83%) were boys, with a median age of 17 years (range 15 to 18 years). All the targeted schools had English as the medium of education.

Table 1. Pre and post-workshop assessment questions and their expected answers

Sl.	Questions	Expected answers
1	Does being healthy means our body is free from microbes?	No
2	Can we visually detect the presence of microbes on our hands with the naked eye?	No
3	All microbes on our hands are bad for us	Some are good (or commensal) and some are bad
4	Hand hygiene is important as	Both options • It will clean my soiled hands • It will reduce the disease-causing bacteria on the hands
5	Proper handwashing requires	Washing hands with appropriate soap/ disinfectant for 20-30 seconds
6	Antibiotics are used to cure ……. infections	Only bacterial infections
7	Antibiotics can kill…….	Both good (or commensal) and bad bacteria
8	I believe that antibiotics can cure all our coughs and colds	No
9	I can use the leftover antibiotics from my family or friends to treat my illness	No
10	If I feel well after taking only part of the antibiotic course, I should stop taking them as they are costly and can also affect my health	No
11	If I have mild illnesses, I can directly go to the drugstore and take antibiotics instead of seeking the doctor's advice	No
12	The misuse of antibiotics in my pet/farm animals have no direct or indirect impact on my well-being	It can have direct or indirect impact on my well-being
13	What is 'antibiotic resistance'?	It is the resistance of the bacteria towards targeted antibiotics
14	What give rise to antibiotic resistance?	All the provided options (i.e., indiscriminate use of antibiotics in healthcare; indiscriminate use of antibiotics in animal husbandry; and improper discarding of antibiotics in the environment)
15	Have you heard about the term 'Superbugs'?	Yes

The average duration of the workshops was 3 hours and 30 minutes. A pre-workshop assessment quiz was organized to assess the baseline knowledge of the participants. During the module lecture session, the main emphasis was given on the concepts like microbial growth, how microbes affect our health, the difference between antibiotics and antimicrobials, a historical overview of antibiotic discovery and timeline, mechanisms of AMR, factors accelerating AMR with examples, how the injudicious use of antibiotics can influence the AMR at human-animal-environment interfaces, common myths in context with antibiotic usage, and what we can do as a community to tackle AMR. To enhance students' comprehension of the impact of antibiotics on microbial growth, we displayed Petri plates with cultured commensal *E. coli* and antibiotic sensitivity testing plates. Additionally, we provided a demonstration using both a paracetamol strip and an amoxicillin strip to illustrate the differences. Following the teaching module session, a discussion was conducted, and it was followed by a post-workshop assessment quiz to evaluate the program's effectiveness. An overview of pre and post-workshop assessment quizzes scoring is provided in Table 2.

Table 2: Comparison of pre and post-workshop quizzes

Sl.	Questions	Session	Correct	Incorrect	p-value
1.	Does being healthy means our body is free from microbes?	Pre	26.09% (36/138)	73.91% (102/138)	<0.00001*
		Post	93.48% (129/138)	6.52% (9/138)	
2.	Can we visually detect the presence of microbes on our hands with the naked eye?	Pre	89.85% (124/138)	10.15% (14/138)	0.02*
		Post	98.55% (136/138)	1.45% (2/138)	
3.	All microbes on our hands are bad for us	Pre	20.29% (28/138)	79.71% (110/138)	<0.00001*
		Post	95.65% (132/138)	4.35% (6/138)	
4.	Hand hygiene is important as	Pre	97.10% (134/138)	2.90% (4/138)	0.34
		Post	98.55% (136/138)	1.45% (2/138)	
5.	Proper handwashing requires	Pre	98.55% (136/138)	1.45% (2/138)	0.35
		Post	100% (138/138)	-	
6.	Antibiotics are used to cure …… infections	Pre	33.33% (46/138)	66.67% (92/138)	<0.00001*
		Post	93.48% (129/138)	6.52% (9/138)	
7.	Antibiotics can kill……..	Pre	36.96% (51/138)	63.04% (87/138)	<0.0001*
		Post	89.85% (124/138)	10.15% (14/138)	
8.	I believe that antibiotics can cure all our coughs and colds	Pre	21.74% (30/138)	78.26% (108/138)	<0.0001*
		Post	89.13% (123/138)	10.87% (15/138)	
9.	I can use the leftover antibiotics from my family or friends to treat my illness	Pre	49.27% (68/138)	50.72% (70/138)	<0.0001*
		Post	94.93% (131/138)	5.07% (7/138)	
10.	If I feel well after taking only part of the antibiotic course, I should stop taking them as they are costly and can also affect my health	Pre	23.19% (32/138)	76.81% (106/138)	<0.0001*
		Post	81.16% (112/138)	18.84% (26/138)	
11.	If I have mild illnesses, I can directly go to the drugstore and take antibiotics instead of seeking the doctor's advice	Pre	56.52% (78/138)	43.48% (60/138)	<0.0001*
		Post	95.65% (132/138)	4.35% (6/138)	
12.	The misuse of antibiotics in my pet/farm animals has no direct or indirect impact on my well-being	Pre	20.29% (28/138)	79.71% (110/138)	<0.0001*
		Post	86.23% (119/138)	13.77% (19/138)	
13.	What is 'antibiotic resistance'?	Pre	31.16% (43/138)	68.84% (95/138)	<0.0001*
		Post	98.55% (136/138)	1.45% (2/138)	
14.	What give rise to antibiotic resistance?	Pre	28.26% (39/138)	71.74% (99/138)	<0.0001*
		Post	98.55% (136/138)	1.45% (2/138)	
15.	Have you heard about the term 'Superbugs'?	Pre	17.39% (24/138)	82.61% (114/138)	<0.0001*
		Post	100% (138/138)	-	

*Denotes statistically significant difference in the correct response data during pre and post-assessment quizzes

Addressing the issue of AMR at the community level remains a significant objective of WHO's Global Action Plan (WHO, 2015) as well as India's National Action Plan (Ranjalkar and Chandy, 2019). Many efforts are carried out by various stakeholders to sensitize the masses for the judicious use of antimicrobials (Mitchell *et al.,* 2019). In the recent past, some of the community-based intervention programs like, European Antibiotic Awareness Day (EAAD) (https://antibiotic.ecdc.europa.eu/en); Community Arts Against Antibiotic Resistance in Nepal (CARAN) (https://ahc.leeds.ac.uk/languages/dir-record/research-projects/730/community-arts-against-antibiotic-resistance-in-nepal-caran); 'Anti-Microbials in Society' (AMIS) (https://www.lshtm.ac.uk/research/centres-projects-groups/amis-hub) project conducted in the United Kingdom, Thailand, and Uganda, coordinated by London School of Hygiene & Tropical Medicine; United Kingdom Health Security Agency sponsored 'e-bug' program(https://www.e-bug.eu/),thecommunity antimicrobial stewardship program 'Do Bugs Need Drugs?' (https://dobugsneeddrugs.org/), hosted by British Columbia Centre for Disease Control; the Centers for Disease Control and Prevention (CDC) 'Get Smart: Know When Antibiotics Work' and 'Get Smart for Healthcare' campaigns (http://www.cdc.gov/getsmart), showed the promising effect of systematic and meaningful public engagement.

In India, limited number of studies have been reported among school students to create and assess the efficacy of AMR intervention programs (Kotwani *et al.,* 2016; Fernandes *et al.,* 2019). In the present study, we observed that the basic concepts regarding AMR are lacking due attention in the regular course curriculum of the schools, even in the medical stream. The scoring of pre and post-assessment quizzes reflects that apart from hand hygiene, other topics related to antibiotic usage and AMR were inadequately addressed by the students during the pre-assessment quiz session. In addition, during the discussion session, many myths regarding the use of antibiotics were highlighted, for example, antibiotics can cure any disease, antibiotic resistance means that our body becomes resistant to antibiotics, there are no side effects of taking antibiotics, the costly antibiotics result better in treating infections, antibiotics are effective against coronavirus, leftover antibiotics can be used by other family members, and the issue of antibiotic resistance concern only those who are repeatedly taking antibiotics. Around 57.97% of students (80/138) were not in a position to differentiate between amoxicillin and paracetamol. Majority of the students (79.71%) were unaware that AMR in animals can directly or indirectly affect the community. It is essential to increase understanding about the path antibiotics take from food production facilities to the consumer's plate through animal sources in order to prevent the proliferation of AMR. However, a significant improvement in the scoring of almost all the questions was observed during the post-workshop assessment, which reflects the importance of such knowledge-based awareness campaigns. Overall, a significant (p-value <0.05) improvement was observed in the median post-workshop scores of the students (i.e., 14/15) as compared to median pre-workshop scores (i.e., 8/15). Our results endorse the importance of educating school students about microorganisms and infections while nurturing a scientific interest in shaping their behaviour with regard to safe antibiotic usage. Incorporating a similar educational module into the standard school curriculum holds the potential to be an effective strategy for addressing AMR, especially when accompanied by ongoing regulatory support in the future.

The present study had some limitations. We adopted the convenient sampling approach by involving schools from Ludhiana city of Punjab, India. The study's findings should be considered within the specific regional context, as education standards can vary across different areas within the same country or state. Moreover, we have targeted medical stream students, owing to their biology subject background, the significant improvement in post-workshop assessment scores might not be extrapolated to other streams of students.

Conclusion

The present study highlights the effect of educational workshops to improve the knowledge of school students on various topics

related to AMR. The only best possible way to protect the efficacy of available antimicrobials is through their judicious use across the One Health sphere (human, animal, and environmental sectors), which mainly relies on sustained community awareness efforts. Therefore, we propose that the principles of AMR and antibiotics usage be included in school curricula so that students can be 'superheroes' in bringing about desired changes in the community through the prudent use of antibiotics.

Conflicts of Interest

All authors declared that there are no conflicts of interest.

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The authors acknowledge the contribution of school principals and teachers in making suitable arrangements for the workshops.

Ethical statement

The permission of the participating students, their school authority and their parents were obtained for their voluntary participation in the study. The identity of the participants as well as schools were kept confidential throughout the study. The study is completely based on the survey where neither any clinical trials nor any collection of sensitive information was carried out.

Annexure 1:

Pre and Post- Workshop Assessment Questions:

Objective of the assessment module:

The objective of this quiz is to analyze the efficiency of the delivery mechanism of the workshop lecture content on '*Know about Antimicrobial Resistance (AMR)'*. Your personal information will be kept confidential, and the data usage will be for academic purposes only.

1. Does being healthy means our body is free from microbes?
   a. Yes
   b. No
   c. I don't know
2. Can we visually detect the presence of microbes on our hands with the naked eye?
   a. Yes
   b. No
   c. I don't know
3. All microbes on our hands are bad for us
   a. Some are good (or commensal), and some are bad
   b. They are always good
   c. They are always bad
   d. I don't know
4. Hand hygiene is important as
   a. It will clean my soiled hands
   b. It will reduce the disease-causing bacteria on the hands
   c. Both
   d. I don't know
5. Proper handwashing requires
   a. Washing hands with plain water for 5-10 seconds
   b. Washing hands with appropriate soap/ disinfectant for 20-30 seconds
   c. I don't know
6. Antibiotics are used to cure …… infections
   a. Only bacterial infections
   b. Only viral infections
   c. Both types of infections
   d. I don't know
7. Antibiotics can kill ……
   a. Only bad bacteria
   b. Both good (or commensal) and bad bacteria
   c. I don't know
8. I believe that antibiotics can cure all of our coughs and colds
   a. Yes
   b. No
   c. Not sure
9. I can use the leftover antibiotics from my family or friends to treat my illness
   a. Yes
   b. No
   c. Not sure
10. If I feel well after taking only part of the

antibiotic course, I should stop taking them as they are costly and can also affect my health
   a. Yes
   b. No
   c. Not sure

11. If I have mild illnesses, I can directly go to the drugstore and take antibiotics instead of seeking the doctor's advice
   a. Yes
   b. No

12. The misuse of antibiotics in my pet/farm animals have no direct or indirect impact on my well-being
   a. It can have direct or indirect impact on my well-being
   b. It doesn't have any direct or indirect impact on my well-being

13. What is 'antibiotic resistance'?
   a. It is the resistance of the bacteria towards targeted antibiotics
   b. It is the resistance of our body for targeted antibiotics
   c. I have never heard of this term before

14. What give rise to antibiotic resistance?
   a. Indiscriminate use of antibiotics in healthcare
   b. Indiscriminate use of antibiotics in animal husbandry
   c. Improper discarding of antibiotics in the environment
   d. All of the above can contribute to it
   e. None of these contribute to it

15. Have you heard about the term 'Superbugs'?
   a. Yes
   b. No

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