KAP Study

Rising tides of resistance: evaluation of healthcare workers awareness regarding artificial intelligence to combat antimicrobial resistance in Pakistan

Guljanan[1], Iqra Saleem[2], Sumera Malik[3], Saba Jamshaid[4], Farrukh Zaman Shah[5], Hubza Ruatt Khan[6]

Abstract

Objective: To determine awareness score regarding the involvement of Artificial Intelligence (AI) to fight against Antimicrobial Resistance (AMR) among the HealthCare Workers of the South and Central Punjab, Pakistan by structured questionnaire to provide actionable educational initiatives and policy recommendations.

Methods: This descriptive cross-sectional survey was done among the HealthCare Workers of South and Central Punjab, Pakistan, between August 01, 2022 and January 31, 2023. The study was limited to Multan and Lahore cities of South and central Punjab, Pakistan was approved by the institutional ethics review board of Nishtar Medical University Multan. A self-created questionnaire was used for collecting data. Version VII of GraphPad Prism was used for the analytical analysis. An independent t-test and analysis of variance (ANOVA) were employed to verify significance among different parameters of study. A p-value of less than 0.05 was utilized to validate statistical significance.

Results: During the study, 401 participants completed the online survey. The data findings indicate that women 275 (68.6%) was majority of the respondents between the age group range 21 – 40. Most of the HealthCare Workers 200 (49.9%) had done post graduation and fall among the category of Certified Professional Doctors and Researchers. Moreover, majority of the partakers 225 (56.1%) lived in Lahore city. The significant correlation of Total Awareness Score (TAS) among Socio-demographic parameters was analyzed. Post graduate HealthCare Workers (p=0.0001) and certified professional doctors/researchers (p=0.0001) had higher awareness score. In comparison to two different cities, HealthCare Workers of City Lahore (p=0.0324) was observed higher awareness level.

Conclusion: Overall, majority of the HealthCare Workers have higher general awareness regarding the involvement of AI in combating antimicrobial resistance and also their implementation of that awareness is negligible.

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Introduction

In the global health landscape, Artificial Intelligence (AI) and Antimicrobial Resistance (AMR) represent two significant and interrelated challenges. AI presents numerous opportunities in the detection, treatment, and prevention of disease. Although, growing AMR poses a threat to our capacity to treat infections effectively.[1] Antibiotic discovery and development are certainly landmark achievements in the fight against pathogenic microorganisms, with millions of lives saved.[2] However, rapidly increasing antimicrobial resistance (AMR) is an unavoidable consequence of antibiotic overuse and misuse, resulting in a global healthcare crisis.[3] The main factor responsible for the resistance toward a widely used class of antibiotic β-lactams, is the development of β-lactamase by the bacteria.[4] The most prevalent gram-positive bacterial pathogen Methicillin-resistant Staphylococcus aureus (MRSA) has extended throughout the world due to its capability to expressβ-lactamase. Now, this is the main cause of pathogenic infections in both community settings and worldwide healthcare.[5] Gram Negative bacteria such as Klebsiella pneumoniae (K. pneumoniae), Enterobacter cloacae (E. cloacae) and Escherichia coli (E. coli) can also develop resistance to β-lactam antibiotics by gradually producing β-lactamase. As a result, their various subtypes have spread globally.[6] So, the detection and identification of drug-resistant bacteria are particularly important by considering the likelihood that the global situation with AMR could become more severe with time.[7]

The first approach towards conquering this problem would be the detection of bacterial AMR in a quick and effectively manner. This would not only help to discover novel ways to overcome problems, but it would also help to prevent antimicrobial overuse through focussed prescription based on accurate identification. This is where artificial intelligence (AI) comes in, as one of the feasible revolutionary methodologies used for rapid and accurate AMR7 identification.[8] In clinical settings, the significant

[1-4]Department of Pathology, Nishtar Medical University, Multan, Pakistan; [5]South Punjab Hospital Labs, Multan, Pakistan; [6]Department of Microbiology and Molecular Genetics, The Women University, Multan, Pakistan.

Correspondence: Hubza Ruatt Khan. e-mail: hubza.38@wum.edu.pk

ORCID ID: 0000-0002-2206-7797

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utilization of artificial intelligence (AI) presents advantage for sympathetic engagement. AI is considered as a steady and transformative improvement in techniques along with tools required to transform and operate clinical data. In some healthcare domains, the novel development of appropriate and sophisticated AI have supported by the mature data resources. However, there are few AI deployment exist within healthcare delivery system that are utilized with improved process and outcomes.[9]

For the identification of AMR determinants before the utilization of AI tools, it was identified by comparing sequence against databases through bioinformatics and by the antimicrobial susceptibility testing (AST). These methodologies give false negative results in this manner that a large number of true AMR determinants with quite dissimilar sequences to currently identified AMR would be labelled as non-AMR. Moreover, the AST method is time consuming and certain bacteria such as B. forsythus are difficult to culture in vitro by this method.[10] Thus the in silico approach via the utilization of Machine learning (ML) represents an alternate to identify AMR correctly in rapid and efficient way.[11] Machine learning (ML) is a subfield of artificial intelligence that enables a computer to predict specific outcomes employing a learned model by the utilization of a significant amount of experimental data, often known as training data.[10] Several databases, including CARD (Comprehensive Antibiotic Resistance Database)[12] and MegaRES,[13] gather peer-reviewed data on AMR determinants, including the type of bacteria involved, a synopsis of the determinant's mode of action for each class of antibiotic, and the corresponding DNA and protein sequences. These data could be utilized to train algorithms to produce a learned model capable of accurately identifying known or new AMR[14] and even predicting the minimum inhibitory concentration (MIC) of MDR bacteria.[15] For the identification of antimicrobial resistance genes via ML, the DeepARG algorithm is accessible.[14]

In developing countries, inadequate laboratory infrastructure can have an impact on the quality and reliability of pathogen detection and antimicrobial susceptibility tests.[16] HealthCare Workers are the front line of defense in these types of critical situations. So, it is necessary for HealthCare Workers to get knowledge regarding new trends in disease control. Thus, the involvement of AI to combat AMR is the need of the time. So, this study aimed to evaluate the Awareness Level regarding the involvement of AI in combating AMR among the HealthCare Workers of South Punjab, Pakistan.

Material and methods

It was a cross-sectional social media based survey. Following the emergence of Artificial Intelligence Tools to combat bacterial resistance around the globe, this study was done to know the awareness level of HealthCare workers regarding general Awareness score of AI tools in combatting Antimicrobial resistance between 01-August-2022 to 31-January-2023. Ethical approval was approved by institutional review board of Nishtar Medical University Multan. Simple random sampling technique was used to collect the data from healthcare workers of Multan and Lahore. This study included 401 HealthCare Workers as participants. Participation was fully voluntary, and all participants received consent forms prior to data collection to describe the research's rationale and its importance. Written consent of participants was taken. The sample size was determined based on known principles for community health research, taking into account practical limits and expert advice for early studies.[16]

In this study, the inclusion criteria for participants consisted of healthcare workers including professional doctors, nurses and researchers practicing in South Punjab, Pakistan, with a minimum of one year of professional experience. The exclusion criteria were healthcare workers on temporary contracts or internships.

The group of experts created the questionnaire. In the questionnaire, demographic parameters were age, gender, level of education, healthcare worker status, area of residency and the questions "Do you know about Artificial Inteligence (AI)" as well as "Do you know about bacterial resistance?" The second section of the questionnaire contained very general questions regarding Awareness of AI in relation to Antimicrobial resistance. All these questions were based on "yes" and "no" answers. One mark for "yes" response was assigned for each question while no mark was given to "no" answer. The Total Awareness Score (TAS) was assessed on a scale of 0 to 7, with the highest score indicating greater awareness of the AI in relation to Antimicrobial Resistance.

Graph Pad Prism Software, Version VII was used to analyze the records, and MS-Excel was utilized to generate descriptive statistics like percentages and numbers. An independent t-test and analysis of variance (ANOVA) were applied to examine the association between the Awareness towards AI in relation to antimicrobial resistance and socio-demographic factors to verify significance. A p-value of less than 0.05 was determined to indicate statistical significance.

Results

A total of 401 participants completed the online survey during the study. The data findings indicate that women 275 (68.6%) was majority of the respondents between the

age group range 21 – 40. Most of the HealthCare Workers 200 (49.9%) had done post graduation and the category of Certified Professional Doctors and Researchers. Moreover, majority of the participants 225(56.1%) lived in Lahore city. Out of 401 participants, everyone had awareness regarding antimicrobial resistance and least number of respondents 11 (2.7%) had no idea about AI (Figure 1).

About seven questions were designed to evaluate the Total Awareness Score (TAS) of HealthCare Workers regarding artificial Intelligence to combat Antimicrobial Resistance in South Punjab, Pakistan (Figure 2). Overall, majority of the HealthCare Workers have general awareness regarding the involvement of AI in combating antimicrobial resistance but their implementation of that awareness is negligible.

Table: Socio-demographic Characteristics of the Study (n=401)

Characteristics	**Respondents** [n (%)]
Gender	
Male	126 (31.4)
Female	275 (68.6)
Age (years)	
21 – 40	189 (47.1)
41 – 60	144 (35.9)
>60	68 (16.9)
Level of Education	
Diploma Holders	45 (11.2)
Graduate	156 (38.9)
Post Graduate	200 (49.9)
HealthCare Worker Status	
Certified nurses	52 (12.9)
Certified Professional Doctors	171 (42.6)
Certified Professional Doctors + Researchers	178 (44.4)
Cities	
Lahore	225 (56.1)
Multan	176 (43.9)
Do you know about Artificial Intelligence?	
Yes	390 (97.3)
No	11 (2.7)
Do you know about Bacterial Resistance?	
Yes	401 (100)
No	0 (0)

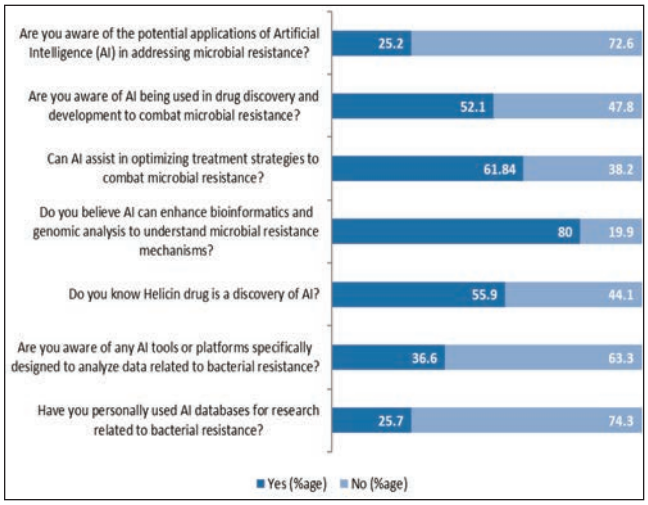

Figure-1: Generalized and basic questions regarding awareness of AI involvement in combating Anti-microbial resistance.

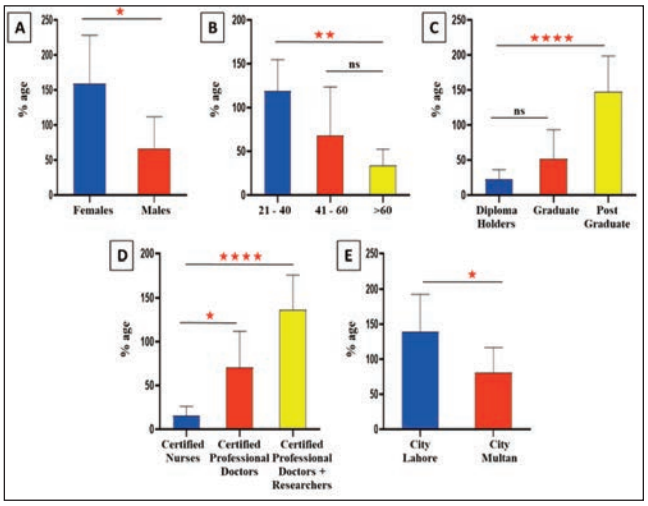

Figure-2: The correlation between the Total Awareness Score (TAS) and socio-demographic variables.

*The association of TAS among (a) Females and Males, (b) Age groups 21-40, 41-60 and >60, (c) Diploma Holders, Graduate and Post Graduate, (d) Certified Nurses, Certified Professional Doctors and Researchers, (e) Lahore and Multan City, ****; Significant (< 0.0001), **; Significant (< 0.007), *; Significant (< 0.027), ns; Non significant (>0.05).*

According to our study, the significant correlation of Total Awareness Score (TAS) among Socio-demographic parameters was analyzed (Figure 2). Females (P-value 0.0116) were significantly higher TAS in comparison to males (Figure 2A). In accordance to other age groups, the TAS was significantly observed higher in age group 21 – 40 (p=0.031) (Figure 2B). Post graduate HealthCare Workers (p=0.0001) (Figure 2C) and certified professional doctors/researchers (P-value 0.0001) (Figure 2D) was observed significantly greater TAS. In comparison to two different cities of South Punjab, the TAS of HealthCare Workers belong to city Lahore (p=0.0324) was significantly increased (Figure 2E).

Discussion

Antimicrobial resistance (AMR) is an increasingly serious threat to global public health[18] and estimated to account for 10 million deaths annually worldwide by 2050.[19] Antibiotic resistance genes (ARGs), acquired through mutations in existing genes or horizontal gene transfer are the primary cause of bacterial resistance. In clinical settings, the increased prevalence of multidrug-resistant bacteria has severely compromised the effectiveness of antibiotic treatments. The rapid development of artificial intelligence (AI) has facilitated the analysis and interpretation of complex data and provided new possibilities to face this

problem.[20]

According to this study, the least amount of healthcare workers are aware of AI applications and databases used to control antibiotic resistance. HealthCare Workers who have worked as researchers have a high level of awareness about AI's role in controlling bacterial resistance. AI is utilized to assist in the diagnosis of antibiotic resistance by examining microscopic photographs of bacterial cultures. Machine learning algorithms such as Convolutional Neural Networks (CNNs) can be trained to detect certain features within these images indicating whether bacteria are resistant to antibiotics. For instance, Hayashi and others employed CNNs in identifying drug-resistant bacteria from high-resolution images captured under a transmission electron microscope (TEM) without exposing the bacteria to antibiotics. The research indicated that resistant bacteria had some alterations in their shape even without drugs. This indicates that genetic alterations associated with drug resistance also result in alterations in their structure that are observable. Other AI techniques such as Support Vector Machines (SVMs) are also being employed to identify patterns in both genetic and microbiological data. Therefore they are being utilized to identify antibiotic resistance.[21,22] Additionally, deep learning algorithms are being utilized to rapidly process antibiotic susceptibility tests (AST). These algorithms are involved in reducing the time required to determine resistance from a few days to a matter of hours.[23] One of the AI methods, Recurrent Neural Networks (RNNs) is especially adept at processing data that fluctuates over time. This allows RNNs beneficial for the analysis of patterns in bacterial growth and the reaction of bacteria towards antibiotics.[24] Artificial intelligence based decision support systems (AI-DSS) hold promising approach for better utilizing antibiotics in the healthcare system. AI-DSS applies sophisticated algorithms to sift through vast amounts of patient data including medical history, laboratory findings and information regarding the bacteria infecting patients. By computing this information, AI-DSS assists healthcare professionals in making more informed choices in prescribing antibiotics so that the appropriate treatment reaches the appropriate patient. This should assist in curbing the misuse of antibiotics and enhancing patient outcomes.[25] In previous study, Lee et al. demonstrated that machine learning algorithms can be applied to predict the cause of an infection as bacterial or viral based on laboratory findings and clinical symptoms. This enables physicians to make more informed decisions regarding when to administer antibiotics.[26] In addition to being helpful in hospitals, AI-DSS can also prove beneficial in community healthcare. This encompasses primary physicians, urgent care centers and long-term care centers assisting such providers in improving the use of antibiotics and complementing overall efforts to avoid overuse of antibiotics.[27]

According to present study, very few healthcare workers employed AI tools to access new information and ideas for overcoming antibiotic resistance. This study proposes a very easy and effective methodology for implementing campaigns to raise awareness of AI technologies for overcoming antibiotic resistance. The research presents a real issue in that healthcare professionals are generally aware of the role AI plays in managing antibiotic resistance, but they are not putting this knowledge into practice. Thus, it's important to educate healthcare professionals about the resources and software that provide them with up-to-date knowledge about antibiotic resistance. With the application of this knowledge, healthcare professionals will be able to recognize emerging trends in medication development and prevent the repeated overuse of antibiotics.

This is first study reported and limited to only two cities of South Punjab, Pakistan. These limitations affect the generalizability of the findings. So, there is also need to evaluate the awareness level at different regions of Pakistan and on the global level.

Conclusion

AI has the potential to anticipate and identify AMR in bacteria in an effective manner. Furthermore, combining machine learning algorithms with laboratory testing can help to accelerate the discovery of new antimicrobials. To date, various machine learning techniques for antimicrobial resistance discovery have been developed and extensively evaluated. This study raises a very real issue: while healthcare workers are generally aware of the role of AI in the management of antibiotic resistance, their execution of that awareness is negligible. As a result, there is a need to educate healthcare workers about the tools and applications that will provide them with access to new details on antibiotic resistance. This information will enable healthcare workers to identify new patterns in drug emergence and restrict the usage of the same antibiotics over and over.

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Author Contribution:

GJ: Literature search, design, concept, questionnaire design, data collection, final approval and agreement to be accountable for all aspects of the work.

IS: Literature search, design, concept, questionnaire design, data collection, analysis, interpretation, drafting, final approval and agreement to be accountable for all aspects of the work.

SM & SJ: Data collection, drafting, final approval and agreement to be accountable for all aspects of the work.

FZS: Data collection, Correction of grammatical mistakes, final approval and agreement to be accountable for all aspects of the work.

HRK: Recheck the data analysis and their significance values, revision, data collection, final approval and agreement to be accountable for all aspects of the work.