Bibliometric Analysis Role of Artificial Intelligence-based Analytics for in Silico Research in Antimicrobial Resistance Prediction and Treatment Development

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Abstract. At a time when technological developments are increasingly rapid, many industrial sectors are using AI to support the effectiveness of human life. One example is that AI can be used to build qualified antimicrobial resistance prediction models based on genomic, epidemiological and biochemical data. AI will then work to identify patterns and factors related to antimicrobial resistance. In this way, researchers can predict the potential resistance of a pathogen to certain antibiotics. By utilizing AI, we can predict molecules that may be effective in disrupting antimicrobial resistance pathways or inhibiting pathogen growth. Apart from that, AI assistance will be useful in designing new drugs with desired properties, because AI can see strong to weak antimicrobial activity, specificity against certain pathogens, and good bioavailability. Other benefits may also help in assessing the risk of antimicrobial resistance to new drug candidates. By analyzing factors such as drug-microbe interactions, potential cross-resistance, and microbial population dynamics, AI can estimate the probability of resistance to a drug under development. The final benefit is that AI can help in personalizing antimicrobial treatment by considering factors such as the patient's genomic profile, treatment history, and local resistance patterns. By utilizing machine learning techniques. Doctors will find AI helpful because AI can provide advice on choosing the most effective therapy and minimizing the risk of resistance. In silico research is becoming increasingly important in efforts to understand, prevent and overcome antimicrobial resistance and develop effective treatments..

Keywords. Artificial Intelligence; Antimicrobial Resistance; VOS Viewer; Indonesian

1. Introduction

In the 21st century, society is faced with a battle against the threat of antimicrobial resistance. Which has become an important call in the health sector throughout the world. Although the discovery of antibiotics has been an important milestone in the treatment of bacterial infections over the past decades, a new challenge that has come to the fore is the rapid evolution of microorganisms becoming increasingly resistant to the antibiotics we have [1]. Therefore, new threats are emerging and may put us at a critical point, where the development of new antimicrobial therapies and innovative prevention strategies becomes urgent [2].

In facing the complexity of modern microbiological dynamics, there are in silico approaches that have become a major highlight in our efforts to predict and overcome antimicrobial resistance. Through artificial intelligence (AI) based analysis it can bring its unique capabilities to analyze and interpret large volumes of genomic, molecular and clinical data related to antimicrobial resistance. Through a combination of machine learning techniques, molecular structure modeling, and computer simulations, The AI allows researchers to explore the complexity of interactions between pathogens and antibiotics, and paves the way for new innovations in medicine [2] [3].

Proper use of AI can be of tremendous benefit to many fields. Because AI users can carry out analyzes that promise very significant progress in two critical areas, namely the prediction of antimicrobial resistance and the development of new therapies. With AI, AI can pay attention to unique patterns in genomic data, apart from that, AI can also help identify potential resistance markers and predict the development of microbial resistance to certain antibiotics. Meanwhile, in the development of new treatments, AI plays a vital role in discovering target molecules, designing more effective drugs, and speeding up the research process from the laboratory bench to the patient [4].

Through an in silico approach driven by artificial intelligence, society has the opportunity to reduce the gap between the rate of evolution of microorganisms and our ability to develop more effective drugs as microorganisms evolve [5] [6]. However, to realize its full potential, there needs to be close collaboration between science, technology and health practitioners and government. In this context, we can see that the role of artificial intelligence-based analysis is an important basis for strengthening the foundations of in silico research that can have a significant impact in global efforts to address the antimicrobial resistance crisis [6]. As we know, the world is facing the problem of antimicrobial resistance which is a growing global health problem that threatens the effectiveness of antibiotics.

This study aims to evaluate the effectiveness of a new machine learning approach in predicting antimicrobial resistance patterns. Researchers used an algorithm from AI where AI is machine learning, which can specialize in performing Random Forest classifiers, to analyze a dataset of 10,000 bacterial isolates. The data included antibiotic susceptibility profiles and genome sequences. The researchers found that the random forest model achieved 85% accuracy in predicting resistance patterns. The model identified previously unrecognized correlations between certain genetic mutations and antibiotic resistance. The model also showed higher precision in predicting the accuracy of multi-drug resistance. This machine learning approach provides a tool that can predict antimicrobial resistance, which can potentially help in the development of targeted treatment strategies for patients. These findings suggest that integrating AI into resistance surveillance could improve our ability to manage and prevent antibiotic resistance

2. Background and Literature Review

In the field of pediatrics, precisely in 1984 one of the first papers on the use of AI was published: and presented several computer-assisted medical decision-making systems called SHELP, this system has another goal, namely to diagnose congenital metabolic disorders experienced by the general public. About 30 years ago the IBM Watson Platform successfully adapted the system and was used at Boston Children's Hospital to provide valuable support in the diagnosis and treatment of very rare childhood diseases. This first system is very helpful in identifying bacteria that cause serious and rare blood infections. Apart from that, this system can also recommend appropriate antibiotic therapy and provide appropriate drug recommendations. Since 1984, there has been a wave of publications regarding the use of AI in various fields of pediatrics, some of these publications covering emergency management or so-called (automated appendicitis risk stratification, diagnostic decision support diagnosis, and a framework for asthma exacerbations and early treatment [7].

In other fields there are infectious diseases in children, where many in the world still have many AI implementation strategies, which can be seen from many things, from the development of new antibacterial drugs to the results of diagnoses carried out by AI and appropriate management of infectious diseases. In the field of pediatrics, antibiotics are one of the drugs most frequently prescribed for children, both in hospitals and in the wider community [8] [9]. For example, regarding the use of AI and its vulnerabilities in the health sector, one example is that many prescriptions are inappropriate or unnecessary to treat diseases, antibiotic treatment is often used in children who suffer from viral infections or even other non-communicable diseases. In other cases, broad spectrum antibiotics prescribed by doctors or medical health are antibiotics with antibiotics that are prescribed as a mistake or to treat infections that require targeted therapy because they already have a certain dose [8].

In addition, the development of antibiotics is no longer considered an economically justifiable investment for the pharmaceutical industry because antibiotics are used for relatively short periods of time and should not be possessed and consumed in the long term, because antibiotic treatment is not like drugs used to treat other chronic diseases. The cost of developing antibiotics, among other things, is much lower than the cost of antibiotic drugs because developing antibiotics takes a long time to be released and achieve the best antibiotic results. As a result, over the past 15 years there has been a significant shortage in the development and availability of new antibiotics to combat emerging resistance from other diseases [10]. Therefore, with the existence of a system, society can implement containment strategies to overcome problems that are growing rapidly at this time. This method is called innovation in an effort known as antimicrobial stewardship (AS), and this method is a very important method, because it has proven to be able to improve antibiotics very well along with resistance from other diseases [11]. The methodology in this study on antimicrobial resistance plays a significant role in providing an understanding and control of the spread of resistance for readers. In this study, researchers describe antimicrobial resistance using qualitative methods where qualitative research used was collected through in-depth interviews with health professionals, which have been used to explore perceptions and practices related to antibiotic use. Research by Smith et al. (2020) shows that interviews can reveal factors that influence adherence to antibiotic use guidelines, although this approach is often limited by small sample sizes and potential subjective bias.

3. Proposed Method

In the research entitled Bibliometric Analysis Analysis role of artificial intelligence-based analytics for in silico research in antimicrobial resistance prediction and treatment development, we researchers conducted an in-depth study regarding planning for the development of an AI system for in silico research in antimicrobial resistance prediction and treatment using literature studies. We, researchers, conducted a review of various literature sources on the internet, including articles, books and journals that are relevant to the subject we will discuss. Our main focus is looking at reference data from the Scopus database using keywords related to system monitoring in silico research in antimicrobial resistance prediction and treatment development. Apart from searching for keywords related to in silico research, other additional keywords are related to antimicrobial resistance prediction and treatment development.

The selection process in the artificial intelligence process for in silico research in antimicrobial resistance prediction and treatment development is carried out by data collection, data integration, feature extraction, prediction model creation, model validation, result interpretation, implementation in clinical practice. Our

data analysis is facilitated through the VosViewer application, through VosViewer researchers can clearly see information and data from previous researchers, and through VosViewer they can explain the identification of overall themes, patterns, and trends in the Scopus literature database. Data extracted from Scopus is exported in CSV file format for further processing using VosViewer. The theoretical framework contained in Scopus is a reference for us as researchers to use in disseminating knowledge and insights regarding technological advances and their use in predicting antimicrobial resistance and developing treatment. We have the ultimate goal of this research, so that the public can see the benefits of using the system in predicting antimicrobial resistance and developing treatments.
Based on the analysis of several previous literatures, it was revealed that many have used the system in predicting antimicrobial resistance and developing treatment, but there are also benefits and risks from implementing the system which will be explained in the results and discussion. Based on the results of previous research, a link has been identified between age location and the system acceptance model in predicting antimicrobial resistance and developing treatment. In addition, data analysis using VosViewer makes it easier to evaluate internal validity, external validity, and reliability of previous research findings. The impact obtained has been documented so that the relevance of applying the system in predicting antimicrobial resistance and developing treatment can be proven to be effective. This research seeks to provide benefits to the wider community so that the data community knows that the system for predicting antimicrobial resistance and developing treatment can enable efficiency in the treatment development process to continue, so that people can save time and recover more quickly if infected. This research also hopes that future researchers will strive to improve the design, implementation and assessment of system interventions in antimicrobial resistance prediction and treatment development.

4. Result and Discussion

The AI-based interventions in the health sector are divided into four categories involving global health researchers, and apart from that, researchers also carry out diagnostic assessments of the risk of morbidity and mortality in each patient. Apart from that, with this system, society can predict and monitor epidemics, as well as health planning. and existing policies. In the healthcare industry, many sources generate this data and the data is generated through multiple analyses, including genome analysis, bibliometric analysis, further collected from medical applications and wearable devices used in healthcare environments, and stored in databases containing medical records or stored in general instructions. The expansion of data coupled with technological advances has evolved and given birth to AI. In 2019 there were research results from Peiffer et al [12]. It found around 60 different ML applications that can be used to support decisions in the management of infectious and other diseases. Its application in health care is endless because diseases continue to develop and undergo continuous change so that in the case of infectious diseases in children, this system can play an important role in fighting antibiotic resistance in the community, and can help reduce the time needed for the development of antimicrobial agents. new, and offers some even more possibilities. Diagnosis and treatment can be done consistently and simultaneously by utilizing AI. Apart from that, we can also see other benefits of AI from the many perceived benefits, such as reducing economic labor and health costs. In addition, AI can be used for health hygiene, infection control, and vaccination at the local, national, and international levels [13]. There are many strategies faced in the application of AI in the context of fighting antibiotic resistance. Although the field is still new, many AI-based health interventions can improve health outcomes in low- and middle-income countries due to their low cost. However, to implement AI, more research is needed regarding the ethical, regulatory, or practical considerations needed so that AI can be widely used and put to its best use. The global health community must work rapidly to establish development, testing, and use guidelines and develop a user-driven research agenda to facilitate fair and moral use. AI has achieved a level of precision in healthcare that was unimaginable just a few years ago, but there are still many limitations that still make implementing care processes difficult. First, the lack of specifically in the pediatric field, randomized clinical trials demonstrating increased reliability and/or effectiveness of AI systems compared to traditional systems in diagnosing infectious disease infections or recommending appropriate treatment creates distrust on the part of physicians regarding these diseases [14].

The AI culture in the world is still lacking in adapting to the problems that exist among health professionals, many doctors in this case, especially pediatricians – have never heard about the benefits of AI in the world. Another limitation is the methodological use that can arise from these systems especially in terms of vulnerability, as these systems are often based on studies, databases and guidelines from other countries and thus may not be representative of all patients. Another related limitation relies on the need for large amounts of data [15] [16]. Depending on the complexity of the AI/ML architecture used, data requirements may increase (e.g. deep neural networks require large amounts of data). In addition, the data required must not only be large in size but must also be of high quality, both in terms of data cleaning and data variability (NN and DNN tend to overfit data if there is variation, for example the variance is limited). There are also some applications in pediatrics that require variable data collection drawn from clean, certified, and large amounts of data that may be difficult or even impossible. Other topics relate to the protection of privacy and security for example, we can consider the need for consent for the processing of personal health data by artificial intelligence systems. We also need to think about how to integrate this system into the work environment of doctors and nurses in hospitals [17] [18].

4.1. Design an antimicrobial resistance prediction and treatment development

In Figure 1 below, is a network visualization image consisting of several entities such as authors, keywords, and edges that represent relationships between entities. On the other hand, the link density between nodes can be interpreted to indicate the link density in a data set obtained from the Scopus database. There is a closeness between the connections between points in this view which shows the strength and frequency of connections between different objects using certain keywords

Based on the image above, a set of connected patterns can represent interconnected elements and have a significant influence on the antimicrobial resistance prediction. Researchers can use density analysis to identify key indicators or risk factors for inflation. Determine the goal of designing new drugs that are more effective against resistant microorganisms, further collecting relevant data for research purposes. This may include genomic, epidemiological, clinical, and molecular data from a variety of sources such as public databases, laboratory studies, and patient medical records.

Next, the most relevant and informative features need to be selected from the processed data. This can be done through statistical analysis and in-depth domain understanding of antimicrobial resistance and drug development mechanisms. Selection of AI models and algorithms involves feeding the model with training data and adjusting the model parameters to match patterns in the data. After training, the model needs to be validated and evaluated using independent validation data. This is important to ensure that the model has good generalization ability and is reliable in predicting antimicrobial resistance or designing new drugs.

Model tuning and optimization processes may be necessary to improve model performance. This involves adjusting model parameters, selecting additional features, or using clustering techniques to improve prediction accuracy. Ultimately, the results from AI models need to be interpreted by researchers and health practitioners [19]. This involves further analysis of factors influencing antimicrobial resistance, discoveries about new target molecules, or recommendations about tailored treatments. By following these steps, artificial intelligence design for in silico research in antimicrobial resistance prediction and treatment development can produce powerful and effective models in helping to address the increasingly complex challenge of antimicrobial resistance [20].

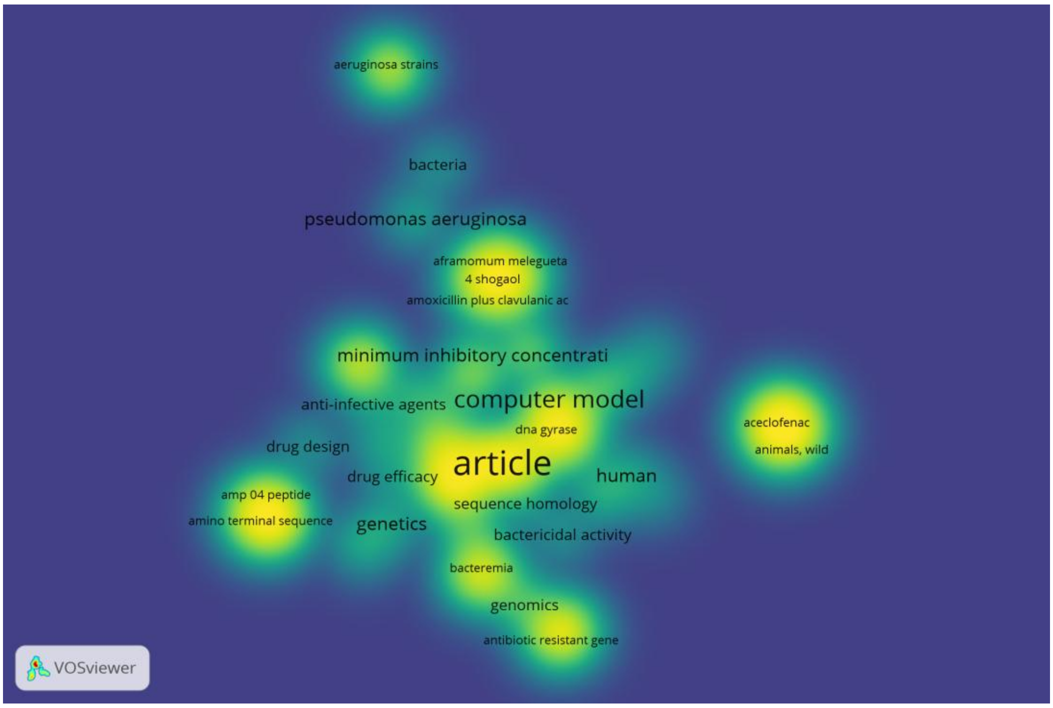

Figure 1. Density Visualization

Here is a data table that explains about antimicrobial resistance of various pathogens. The table can show the percentage for resistance of each pathogen and antimicrobial, here is a table that shows the percentage for resistance of each pathogen and antimicrobial.

Table 1. Antimicrobial resistance of various pathogens

Pathogen	Antimicrobial	Resistance Rate
E. Coli	Ciprofloxacin	35%
S. Aureus	Methicillin	60%
P. Aeruginosa	Gentamicin	25%

The Table 1 above shows that resistance to ciprofloxacin in E. coli has increased by 10% in the last two years according to data from previous studies. With the above data showing a worrying problem where we must find a new approach in controlling antimicrobial resistance. Here are the main benefits of AI in conducting antimicrobial resistance: Analysis of large and complex data, for example, there are deep learning algorithms such as convolutional neural networks (CNN) that can be used to analyze bacterial culture images and identify resistance patterns that are not visible with conventional analysis. With this method, it can increase efficiency in processing and analyzing big data, save time and resources, reduce the possibility of manual errors and increase accuracy identifying resistance patterns.

The second is where AI can perform faster detection and diagnostics, for example, there is an AI system based on microscopic image analysis that can detect resistance based on changes in bacterial morphology induced by antibiotics. The advantage of this AI system is that the response time is very fast and reduces the risk of spreading infection, while also increasing the accuracy of resistance detection and reducing human error.

The third example is resistance prediction and modeling where there are machine learning models such as logistic regression and decision trees that can usually be used to predict the risk of resistance based on antibiotic use patterns and epidemiological data. Furthermore, an example of AI that can be personalized for antibiotic therapy, an example of its use is that AI algorithms can integrate data from pathogen genetic test results and patient medical history to recommend the most effective antibiotics. By effectively leveraging AI tools, antimicrobial resistance research can become more efficient, accurate, and innovative, which in turn can improve resistance control strategies and health outcomes worldwide.

4.2. Assess the effectiveness of using the prediction of antimicrobial resistance and treatment development to see the benefits and drawbacks when it will be implemented in Indonesia

The following in Figure 2 is an overlay visualization image and uses "the prediction of antimicrobial resistance" as the keyword. Readers can see the relationship between relationships and factors that influence these keywords. Researchers can provide readers with a comprehensive visualization of variables that are related to each other. The overlay visualization provides information about the prediction of antimicrobial resistance. It can be seen that the benefits and effectiveness of using the prediction of antimicrobial resistance system in increasing public and government awareness are very positive.

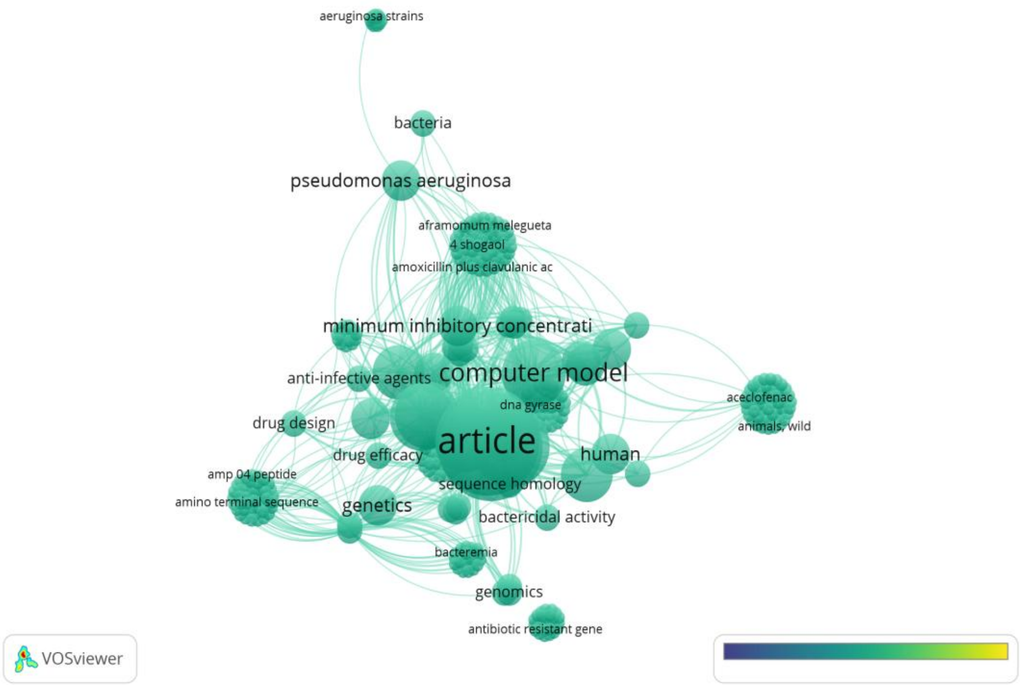

Figure 2. Overlay Visualization

4.3. 4.3. Identify community challenges for integrating the prediction of antimicrobial resistance system

The following Figure 3 is a network visualization image using keywords related to 'antimicrobial resistance prediction and treatment development'. From the figure, through network visualization, researchers can identify central points that represent the main determinants or influences of antimicrobial resistance, as well as groups that are interconnected and show interconnected risk factors. The community's challenge in integrating antimicrobial resistance prediction and treatment development services can be seen from the limited internet network that does not yet reach remote areas of Indonesia. There are still people with economically disadvantaged factors who cannot yet own a smartphone, and finally there are still people who do not know how to use a smartphone, especially the elderly.

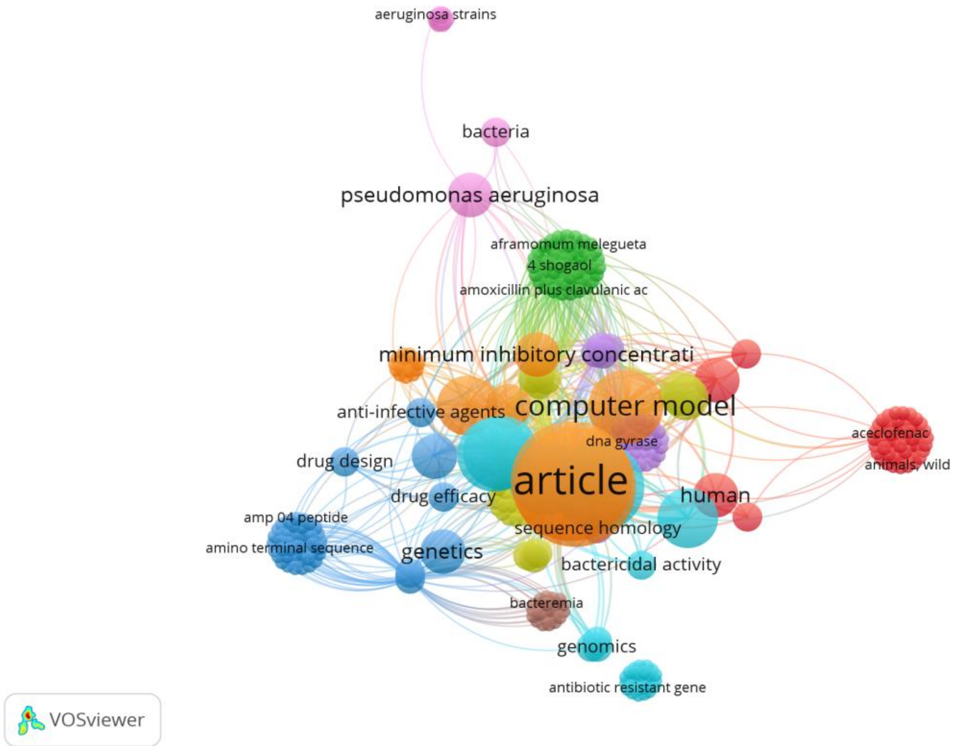

Figure 3. Network Visualization

5. Conclusion

Based on bibliometric analysis of the role of artificial intelligence (AI)-based analytics in in silico research for the prediction of antimicrobial resistance and treatment development, several conclusions can be drawn that there is increasing interest that continues to grow from year to year in the use of AI for in silico research in the context of antimicrobial resistance and treatment development. This is reflected in the significantly increasing number of publications in this field over the last five years from 2019 to 2024. In silico research in antimicrobial resistance and treatment development is increasingly adopting a variety of artificial intelligence-based analytical methods, including machine learning, deep learning, and AI approaches other. This shows that AI is an important foundation in understanding the complexity of antimicrobial resistance. In addition, concrete predictions are urgently needed for use in predictions, this research highlights the need for society and health stakeholders to identify patterns and trends in antimicrobial resistance and prevent the development of mutations and adaptation of microorganisms to treatment.

The role of AI in Therapeutic Development plays an important role in accelerating the development of new antimicrobial therapies by enabling the identification and optimization of compounds that have the potential to become new drugs or increase the effectiveness of existing drugs. Challenges and opportunities are also found in implementing this AI system, although much progress has been achieved, there are still challenges in integrating diverse data, validating AI models, and ensuring the safety and effectiveness of the resulting therapy. However, there is a huge opportunity to overcome these challenges through cross-disciplinary collaboration and the development of more advanced AI technologies. Thus, in silico research that uses AI to predict antimicrobial resistance and develop therapies has great potential to make a significant contribution to efforts to overcome antimicrobial resistance globally.

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