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Superbacteria: The War We're Going To Lose Without AI And Big Data

Julia Meshcheryakova and Denis Tomilin | August 12, 2023

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The Problem Of Antibiotics Resistance: Severity

Antibiotic resistance has become a critical global health challenge, posing a severe threat to human life. Superbugs are bacteria resistant to multiple types of antibiotics. They have been steadily spreading, rendering most potent existing drugs ineffective. The consequences of antibiotic resistance are dire, with millions of people affected each year and an estimated 23,000 deaths annually in the United States alone [1]. The World Health Organization (WHO) has recognized antimicrobial resistance (AMR) as a major health and development crisis, requiring urgent and coordinated action [2].

The projected rise of antibiotic resistance to 10 million deaths annually by 2050 [3] highlights the urgency of the situation. If left unchecked, antibiotic resistance could surpass cancer, diabetes, and heart diseases as the leading cause of death.

Can we do anything with it at all? Are AI and Big Data just buzz words or inevitable tooling of any modern laboratory?

Importance Of Data

Reliable insights can only be derived from vast amounts of high-quality data. Visiting the "Museum of Mind" in Bethlem Royal Hospital psychiatric hospital a week ago, I was surprised to learn that the idea of keeping patient records is that much new. While the hospital was founded in 1247, the clinical information about the patients was not recorded until 1815.



Figure 1. Photo from Museum of Mind, Bethlem Royal Hospital, London.

Research aimed to fight the problem of antibiotic resistance includes operating with huge amounts of data. Scientists iterate through all possible combinations of chemicals to produce a new potential drug, conducting plenty of experiments and making the conclusions out of them, analyze patients' data to identify correlations. Unfortunately, the raw data is often containerized within the laboratory until the insights are finally (with a significant delay) are published in scientific journals.

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COVID demonstrated the importance of data sharing across the world, but it is still a very early stage of col_lab_oration (couldn't stand but make a pun here). Scientific community lacks the secure and accessible mechanisms to share data among laboratories on a scalable basis.

Technically data-sharing nowadays is not a blocker. All leading public cloud platforms (AWS, Azure, GCP) offer their solutions: they can provide secure and centralized repositories for researchers to contribute and access large datasets, facilitating collaborative research efforts. Nevertheless, regulatory and ethical considerations, alongside a lack of motivation to share data, impede the widespread adoption of these practices.

I believe motivation is one of the key factors here. Imagine you are working on a very important problem, you have your goals, plan to conduct sophisticated set of experiments. And you have the option to share your data with the community. Investing a certain (even if not big) amount of time into non-mandatory routines with no direct reward. No surprise, you'll focus on your study and actions mandatory for it. Maybe some swap schema can work: you bring data – you get access to the data, along with financial stimulation from governmental and commercial organizations. Governments shall be interested in reducing costs for treatment, preventing pandemics, pharmacies – in facilitating the research, to reduce the drug production cycle in time and money.

How Machine Learning Is Currently Used

First of all, applying Machine Learning (ML) to healthcare and life science is not some distant future. It's already here. ML algorithms analyze large datasets, identifying patterns and extracting meaningful insights that aid researchers and healthcare professionals in several ways.

Using ML methods, scientists from McMaster University and the Massachusetts Institute of Technology discovered *abaucin*, a new antibiotic with narrow-spectrum activity against *Acinetobacter baumannii*, a deadly multidrug-resistant superbug.

Through screening thousands of molecules, a neural network identified *abaucin*'s antibacterial properties, which perturb lipoprotein trafficking. This breakthrough showcases the potential of AI in antibiotic discovery, offering a promising lead against a challenging Gram-negative pathogen [18].

The Australian Department of Health and Aged Care cooperated with SuperbugAI Flagship who is developing a hospital tracking and response system to detect superbugs. The system shall also support personalized treatment to improve patient survival and control outbreaks sooner [19].

Other Potential Use Cases

The use cases of AI application are not limited to the mentioned scenarios.

We can analyze data from hospitals, pharmacies, and other healthcare facilities to detect unusual patterns in drug prescription and patient admission rates. Such early detection can facilitate rapid response to emerging outbreaks.

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ML-powered systems can track and analyze antibiotic usage to identify regions with high antibiotic consumption rates. This data can inform targeted intervention strategies and educational campaigns to promote responsible antibiotic use.

Real-time monitoring of antibiotic-resistant strains can aid public health officials in understanding the spread and evolution of superbugs, thus facilitating more effective response measures.

By leveraging ML, scientists can simulate and predict the efficacy of potential antibiotics, reducing the need for expensive and time-consuming laboratory experiments.

We can analyze how environmental factors such as pollution and climate change contribute to the spread of antibiotic resistance [6]. This can help policymakers design more effective strategies.

By analyzing genetic data, we can detect genetic markers associated with resistance, helping clinicians make informed decisions about antibiotic prescriptions. Similarly, antibiotic treatments can be tailored to individual patients based on their specific genetic makeup, medical history, and other relevant factors. Personalized treatment plans can improve patient outcomes and minimize the risk of resistance development.

AI and Big Data are the modern tooling of any scientific laboratory. No chemical lab can do without a microscope for many decades. Now it's time to equip every researcher with data science solutions to make it truly industry standard.

Conclusion

In the face of the alarming threat posed by superbacteria, the integration of AI and Big Data into the traditional scientific flow has become imperative. The use of Machine Learning algorithms to analyze vast datasets and extract meaningful insights has already shown promise in the fight against antibiotic resistance. However, it is crucial to address the challenges of data sharing and collaboration to fully leverage the potential of AI. The community needs to be stimulated and trained to accumulate comprehensive datasets. Incomplete data and lack of data introduce a lot of bias and fade the value of the model whatever good it is.

While the ultimate outcome of this war against superbacteria remains uncertain, one thing is clear: without AI and Big Data, our chances of success are significantly diminished. Having said that I remain an optimistic advocate of a fruitful union of natural sciences and data science. Let's give it a try!

Sources

[A] General info

[1] Stop the Spread of Superbugs: Help Fight Drug-Resistant Bacteria

Date: February 2014 – Source: The National Institutes of Health, part of the U.S. Department of Health and Human Services

Superbugs are strains of bacteria that are resistant to several types of antibiotics. Each year these drug-resistant bacteria infect more than 2 million people nationwide and kill at least 23,000, according to the U.S. Centers for Disease Control and Prevention (CDC). Drug-resistant forms of tuberculosis, gonorrhea, and staph infections are just a few of the dangers we now face.

[2] Antimicrobial resistance

Date: 17 November 2021 – Source: World Health Organization

AMR is a global health and development threat. It requires urgent multisectoral action in order to achieve the Sustainable Development Goals (SDGs).

[3] The Rise of the Superbacteria

Date: 18 December 2019 – Source: Telegraph India

Antibiotic resistance is projected to rise to 10 million by 2050

Antibiotic resistance causes 7,00,000 deaths annually worldwide by rendering 'work-horse' drugs ineffective. Without effective intervention, the number of deaths due to antibiotic resistance is projected to rise to 10 million by 2050, surpassing the toll taken by cancer, diabetes and heart diseases.

If left to the free market, it would be too late to tackle the emerging problem of antibiotic resistance. In addition to having strict regulations regarding the use of antibiotics and pesticides in agriculture and livestock farming, policies must encourage investments in developing new antibiotics.

If we do not act before it is too late, we might witness the recurrence of the 'Black Death' episode in which a bacterial infection epidemic killed millions of people.

[6] Climate change is contributing to the rise of superbugs, new UN report says

Date: 7 February 2023 – Source: CNN

Climate change and antimicrobial resistance are two of the greatest threats to global health, according to a new report from the United Nations Environment Programme.

The [report](#), titled "Bracing for Superbugs," highlights the role of climate change and other environmental factors contributing to the rise of antimicrobial resistance. It was announced Tuesday at the Sixth Meeting of the Global Leaders Group on Antimicrobial Resistance in Barbados.

[18] Scientists use AI to discover new antibiotic to treat deadly superbug

Date: 25 May 2023 – Source: The Guardian

AI used to discover abaucin, an effective drug against *A baumannii*, bacteria that can cause dangerous infections

Scientists using artificial intelligence have discovered a new antibiotic that can kill a deadly superbug.

According to a new [study](#) published on Thursday in the science journal Nature Chemical Biology, a group of scientists from McMaster University and the Massachusetts Institute of Technology have discovered a new antibiotic that can be used to kill a deadly hospital superbug.

[19] Using artificial intelligence to stop antibiotic resistant superbug outbreaks in our hospitals

Date: 16 May 2022 – Source: Australian Government – Department of Health and Aged Care

The SuperbugAI Flagship is developing a hospital tracking and response system to detect superbugs. The system will also support personalized treatment to improve patient survival and control outbreaks sooner.

Julia Meshcheryakova

+ posts

Julia Meshcheryakova is Senior ML Engineer for [DataArt](#).

Denis Tomilin

+ posts

Denis Tomilin is Senior Software Developer and Team Leader at DataArt.

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