ALPHACA

March 2025

Public Healthcare

TELEMEDICINE: TRANSFORMING HEALTHCARE ACCESS

Enhancing healthcare access and patient outcomes by leveraging technology to deliver efficient, remote health services

ANTIMICROBIAL RESISTANCE AND CLIMATE CHANGE

Examining the interplay between environmental shifts and rising micro resistance

THE ROLE OF GENOMICS AND BIOTECHNOLOGY IN PERSONALIZED MEDICINE

Personalized genomic medicine enhances patient diagnoses and treatment of diseases.

REGENERATIVE MEDICINE

Harnessing the body's healing processes to repair and regenerate tissues using advanced techniques.

IMPORTANT NOTICE:

There is **no original research** in this publication. All information provided is an **interpretation** of the articles cited meant for younger audiences interested in STEM.

All due credits are given to the authors of the cited articles.
Do not use this publication as an academic reference.

Citations for the articles referenced, listed in the order by which they appear in the journal publication.

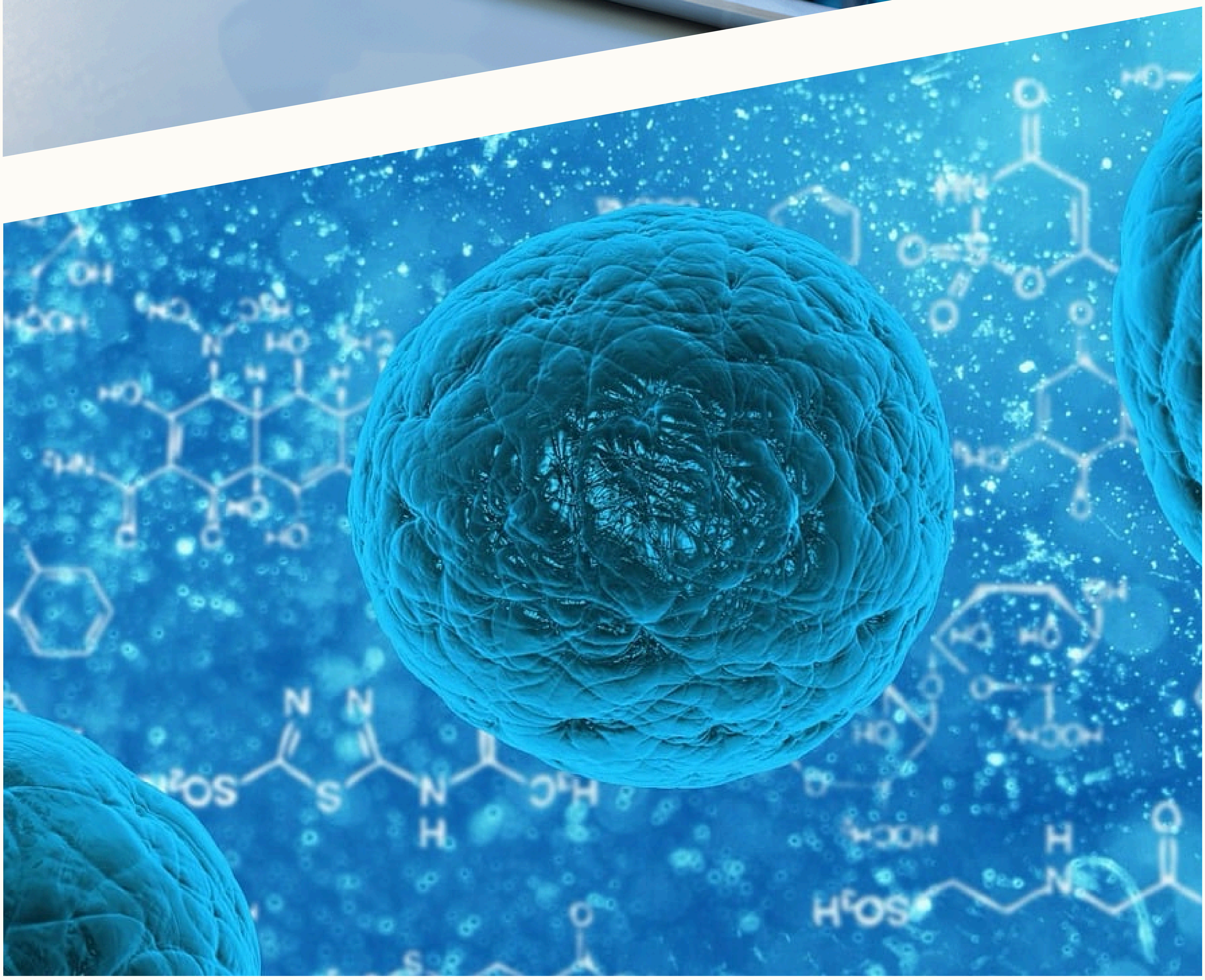
Yue Ma, Chongbo Zhao, Yan Zhao, Jiahong Lu, Hong Jiang, Yanpei Cao, Yafang Xu. "Telemedicine Application in Patients with Chronic Disease: A Systematic Review and Meta-Analysis" (2022) BMC Medical Informatics and Decision Making. Accessed October 20, 2024.
https://bmcmedinformdecismak.biomedcentral.com/articles/10.1186/s12911-022-01845-2#Fig6

Roberta Magnano San Lio, Giuliana Favara, Andrea Maugeri, Martina Barchitta, Antonella Agodi. "How Antimicrocbial Resistance is Linked to Climate Change: An Overview of Two Intertwined Global Challenges" (2023) MDPI.
https://www.mdpi.com/1660-4601/20/3/1681

Brunicardi, F. C., Gibbs, R. A., Wheeler, D. A., Nemunaitis, J., Fisher, W., Goss, J., & Chen, C. (2011). Overview of the development of personalized genomic medicine and surgery. World Journal of Surgery, 35(8), 1693-1699. https://doi.org/10.1007/s00268-011-1056-0

Armstrong, J. P. K., Keane, T. J., Roques, A. C., Patrick, P. S., et al. (2020, December 2). A blueprint for translational regenerative medicine. Science translational medicine.
https://pmc.ncbi.nlm.nih.gov/articles/PMC7610850/

CONTENTS

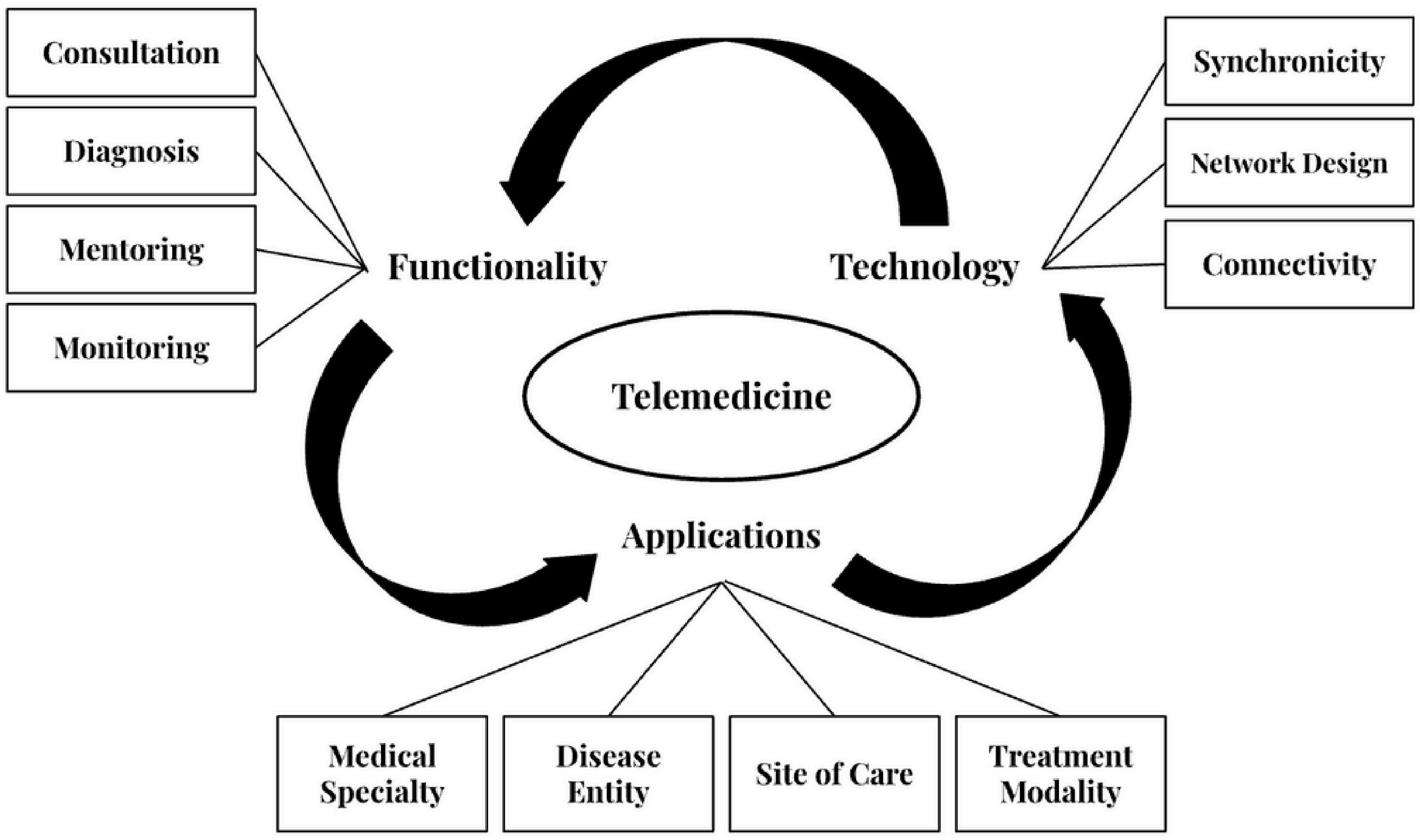


Telemedicine: Transforming Healthcare Access

Revised by Daniella Ling

INTRODUCTION

During the COVID-19 pandemic, telemedicine emerged as an important solution for helping patients manage their health safely and effectively. This innovative technology enables individuals to consult with doctors and healthcare providers from the comfort of their homes, minimizing the risk of spreading infections. By utilizing telemedicine, many professionals and patients can communicate easily and share medical information, even when they may be physically distant.



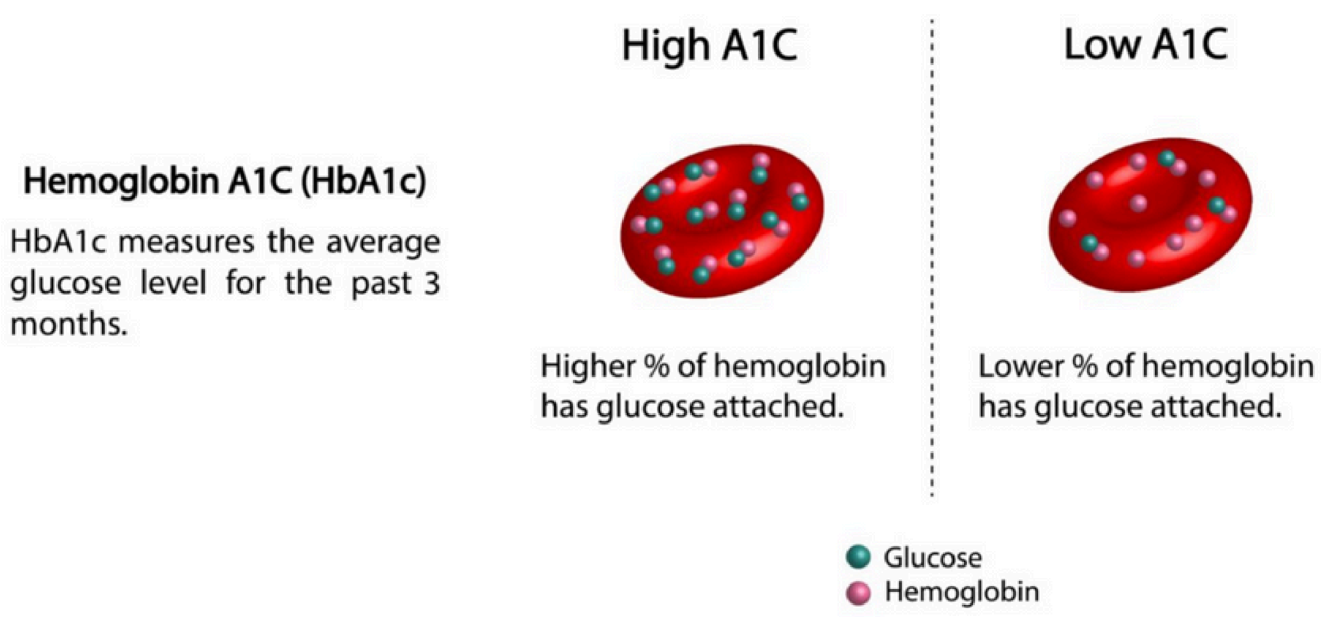
Telemedicine itself is defined as an electronic tool to communicate medical information and connect patients with providers (American Telemedicine Association). There are three main components to telemedicine: the technology employed, functionality, and the applications it can offer. The technology encompasses a variety of tools including video calls, telemonitoring, and online platforms that can facilitate health communication. The functionality includes multiple methods including consultations, diagnoses, general education, and health monitoring. For instance, telediagnosis uses technology to send images and data to healthcare providers, enabling them to make diagnoses without needing an in-person exam. Given the impacts of chronic diseases on individuals and healthcare systems, it is important to also understand how telemedicine can be involved in these conditions. Chronic diseases are long-lasting health conditions that can greatly impact a person's health. These diseases often lead to a decline in well-being, reduced mobility, emotional challenges, and higher mortality rates. Common chronic diseases include hypertension, diabetes, and rheumatoid arthritis. As interest in using telemedicine for chronic disease management increases, but there is still no clear agreement on its overall effectiveness. Therefore, we will examine how this study aims to review and analyze the impacts of telemedicine on managing a variety of chronic diseases.

Effects of Telemedicine in Patients with Chronic Diseases

Telemedicine Intervention Methods:

Telemedicine consultation and telemonitoring are some of the most commonly used telemedicine intervention methods for patients who have diabetes, hypertension, and rheumatoid arthritis (all chronic diseases). Telemedicine consultation involves patients talking directly with their doctors through video or phone calls, allowing them to receive medical advice without needing to go into a clinic. For example, those with diabetes can measure their blood pressure or blood sugar levels at home, which can be sent to their doctors for further review and discussion.

Within this paper, several studies that used methods to help patients with diabetes were analyzed. One study by Han et al. found that after a year of telemedicine consultations, patients' fasting blood glucose (FBG) levels decreased. FBG measures how much sugar is in the blood after fasting, making this an important indicator for diabetes management. However, another study by Sood et al. did not find any significant improvements in a different measure of Hemoglobin A1C (HbA1c) Test, which also depicts the average blood sugar levels throughout the body. This test is also important in understanding blood sugar control as it analyzes the average blood sugar levels over the previous two to three months. Despite this, many other studies showed positive results from telemonitoring; for instance, Feng et al. reported improvements in both FBG and HbA1c levels as patients used telemonitoring.



For hypertension, four studies were examined to analyze the impacts of telemedicine on blood pressure. Hypertension is a condition characterized by consistently high blood pressures that arise from clogged or blocked arteries that can lead to serious health issues like heart disease or strokes. These high pressures arise as the space for blood to travel decreases, so the corresponding pressure exerted onto the blood vessels rises. In one study, after six months of telemedicine consultation, patients experienced lower blood pressure. Another study also found that monitoring blood pressure at home over 12 months helped keep blood pressure stable. High blood pressure can often go unnoticed because it does not typically have any obvious symptoms, but it can significantly increase the risk of health problems, especially in the heart.

Rheumatoid arthritis, which is an autoimmune disease that occurs when the body's immune system mistakenly attacks its joint tissues was also investigated. Two studies that were analyzed looked into the effects of telemedicine consultations. One study found that telemedicine consultations helped reduce anxiety and depression in patients, which are very common among individuals who have chronic pain and/or diseases. The constant discomfort and limitations on physical activity can lead to various emotional challenges, highlighting how mental health supports another important aspect of overall healthcare. The second study demonstrated that while telemedicine did not lead to improvements in any physical systems, it did help patients stick to their prescribed medication plans, which is still crucial in managing their conditions effectively.

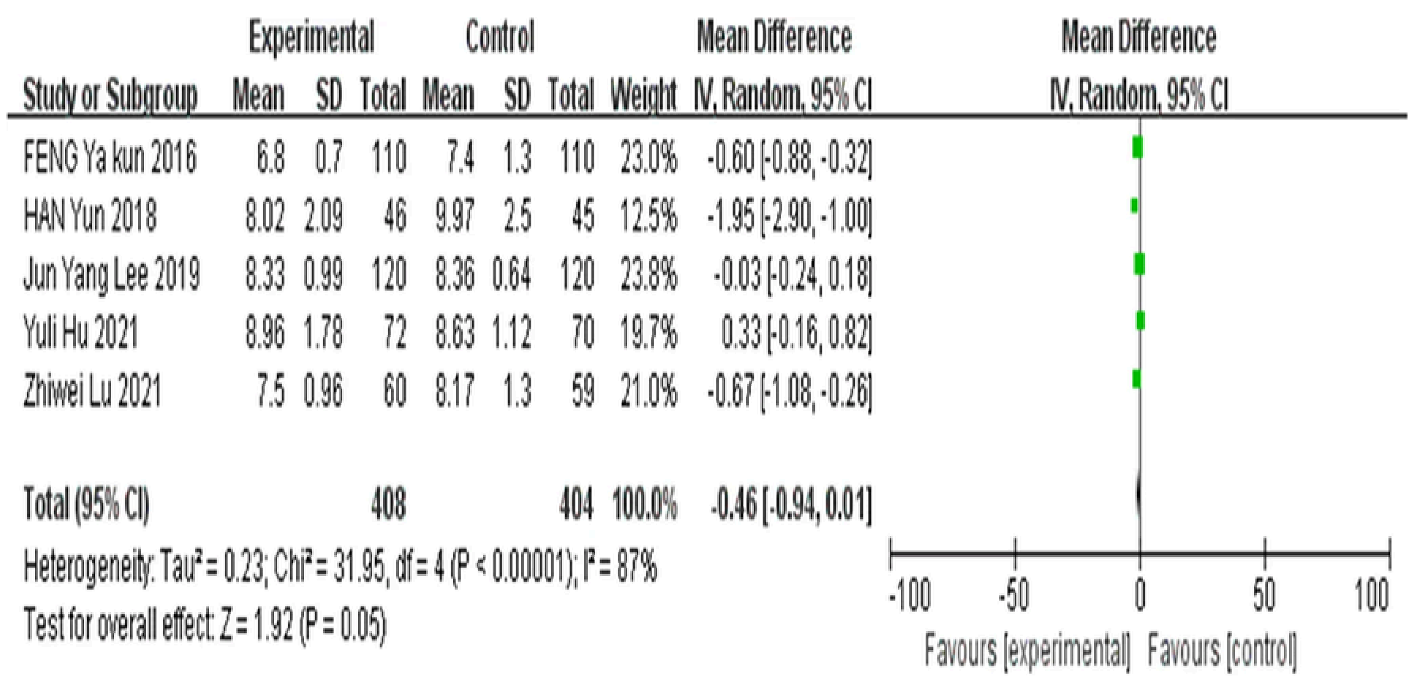
RESULTS

Outcome Measures:

In this paper, a total of fifteen articles were analyzed on how telemedicine could help manage different chronic diseases. The specific important indicators: HbA1c and FBG were determined. To recap, HbA1c is a test that gives an average person's blood sugar levels over the past two to three months, while FBG measures blood sugar after fasting, both indicating how well diabetes is being managed. Additionally, studies analyzing hypertension measured two key numbers: systolic blood pressure and diastolic blood pressure. Systolic blood pressure is the maximum blood pressure during the contraction of the ventricles within the heart (two lower chambers), and diastolic pressure is the minimum pressure just before the next contraction (when the ventricles relax). Combining the results of these studies, a meta-analysis was conducted. This is a statistical method that helps find patterns by pooling data together from various studies. Using this method, we could see if telemedicine is effective in helping patients manage various chronic conditions.

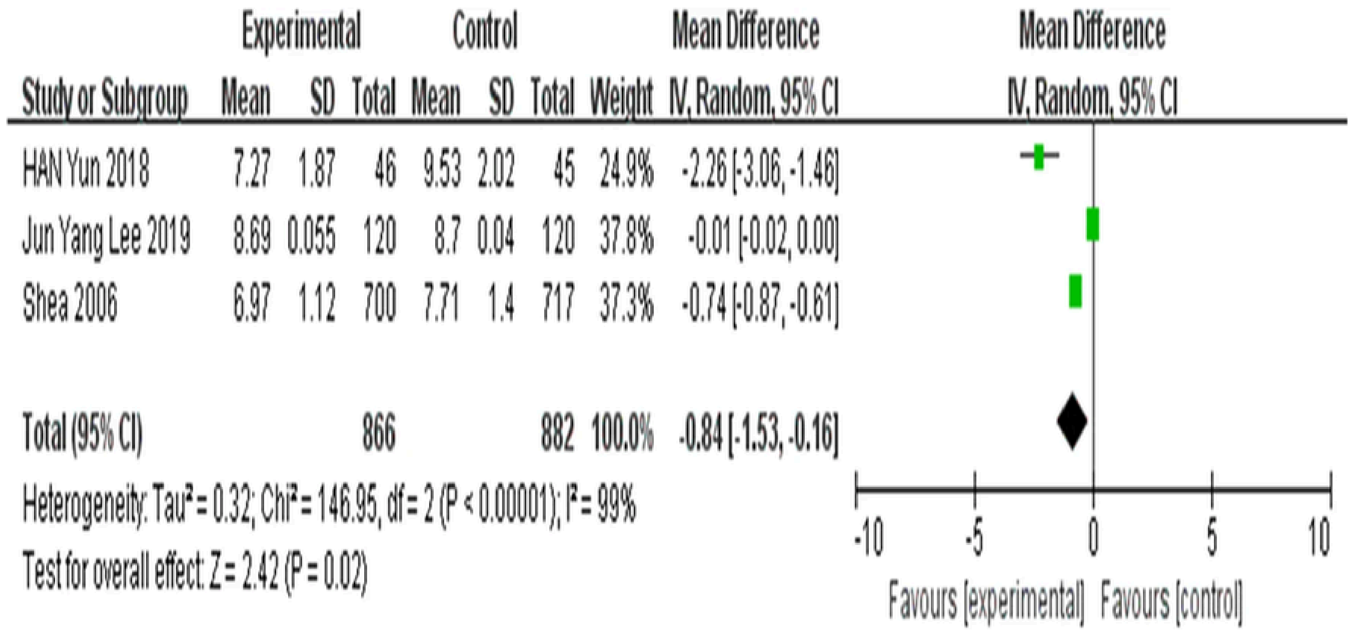
Results of Meta-Analysis

Hypertension after 6 Months:



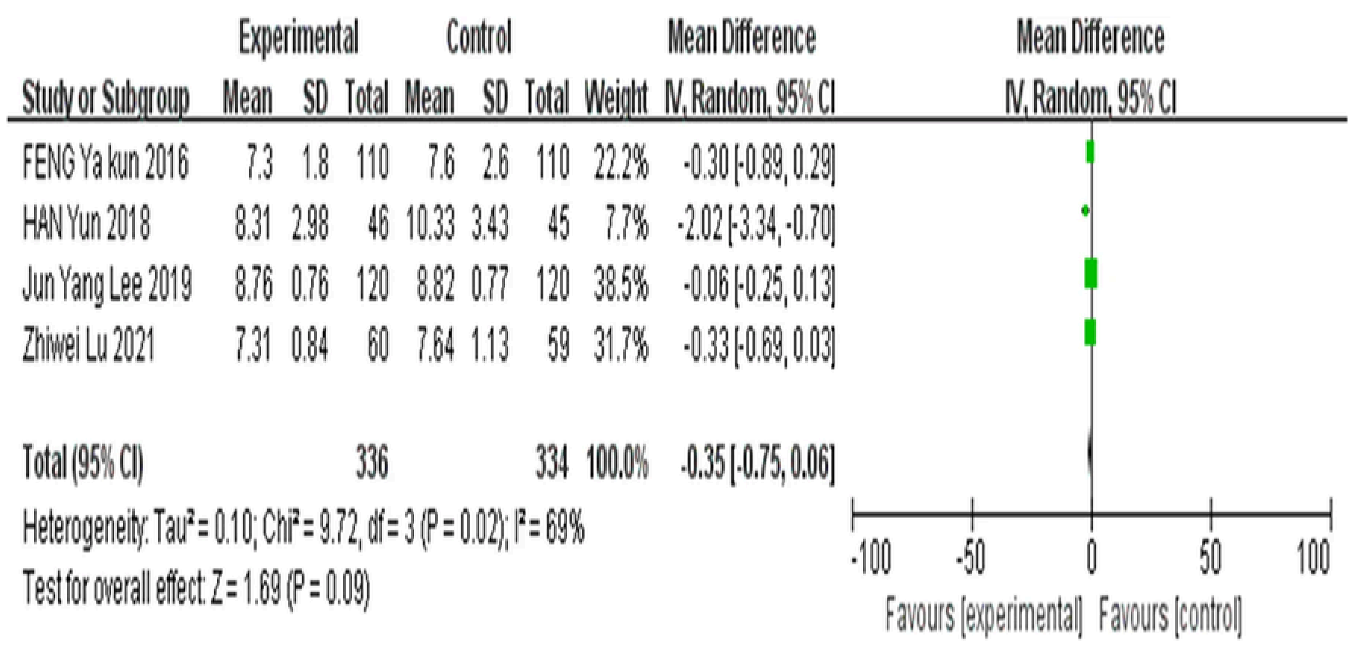
After analyzing the HbA1c results, it was determined that there was a high level of variability in the results indicated by an I2 value of 87% (an I2 value informs the proportion of the variance in the observed effect that is due to variance in the true effects over sampling errors). This indicates that the results from the studies analyzed were different, so to tackle this variability, a random-effects model was conducted. This model assumes the studies represent a random sample, each with its underlying effect size. It is also assumed that there was a mean population effect size about which the study-specific effect varied. After the analysis, it was found that there were no significant differences in HbA1c levels between the group of patients who used telemedicine and those who did not after six months. These findings showed a mean difference (MD) of -0.46 with a 95% confidence interval. This means that the change in HbA1c levels was very close to zero, suggesting telemedicine did not lead to a notable improvement compared to traditional care. Therefore, there was no clear advantage of telemedicine.

Hypertension after 12 Months:



There were high variabilities over the 12-month analysis with an I2 value of 99%. This indicates the results were once also different, so another random-effects model had to be conducted. After that, it was found that there were statistically significant differences between the group using telemedicine and the control group that received regular care. The mean difference was -0.84 with a 95% confidence interval, meaning that the group using telemedicine had a lower average HbA1c level. This means that telemedicine can be an effective tool for managing diabetes when given an adequate amount of time.

FBG after 6 Months:



Using another random-effects model, it was found that there were once again no significant differences in FBG levels. The mean difference was -0.35 with a 95% confidence interval, indicating that while there was a slight reduction in FBG levels for those using telemedicine, it is not enough to be considered statistically significant. This indicates that telemedicine did not lead to any noticeable improvements in FBG levels for diabetes patients over 6 months.

Systolic Blood Pressure:

Results showed a significant difference in systolic BPs between the group receiving telemedicine and the control group. Specifically, there was a 6.71 mmHg reduction in the telemedicine group. This means we can confidently say that telemedicine was effective in lowering systolic blood pressure.

Diastolic Blood Pressure:

Results indicated no significant differences between the telemedicine and control groups. This suggests while telemedicine had slightly lower diastolic BPs, this isn't strong enough to be significant. Therefore, we can't confidently say telemedicine had a meaningful impact on diastolic BPs.

DISCUSSION

Improvments

Duration of Telemedicine Intervention and HbA1c Improvment for Diabetes:

From this paper and its analyzed studies, the length of time patients were involved in telemedicine interventions played a crucial role in improving their HbA1c levels. Compared to the six months, after twelve months of telemedicine, there were much more noticeable differences between the groups that used telemedicine compared to those who did not. This suggests that longer telemedicine interventions lead to better control of blood sugar levels. However, FBG changes were not significant after the six months, highlighting that FBG may not be as reliable of an indicator compared to HbA1c.

Improvements in Systolic BP:

For patients with hypertension, significant improvements in systolic blood pressure were observed after 6 months of telemedicine intervention. The majority of patients saw a notable drop in their blood pressure after 6 months of monitoring through telemedicine. This indicates that telemedicine can effectively assist in managing hypertension.

Positive Effects of Telemedicine on Rheumatoid Arthritis:

Rheumatoid arthritis is a common chronic inflammatory condition that can lead to symptoms like joint pain, nodules, and various systemic issues. Patients often experience long-term joint damage and functional limitations, which can seriously disrupt their daily lives. In addition to physical symptoms, individuals with rheumatoid arthritis frequently face psychological challenges, such as anxiety and depression. These emotional struggles can impact their overall quality of life. Telemedicine has gradually emerged as a key method for managing rheumatoid arthritis. By using telemedicine, patients can experience improvements in their emotional well-being and adherence to medication regimens.

CONCLUSION

This study systematically reviewed the effects of telemedicine on patients with hypertension, diabetes, and rheumatoid arthritis. The findings revealed that telemedicine consultations and telemonitoring are the main strategies used for intervention. Overall, telemedicine proved beneficial for managing these chronic conditions. For hypertensive patients, significant improvements in systolic blood pressure were noted after just 6 months of intervention. Diabetic patients showed more substantial improvements in HbA1c levels after 12 months. Thus, telemedicine has the potential to greatly enhance disease management and overall quality of care.

Based on these results, telemedicine should be recommended as an effective tool for managing chronic diseases. Additionally, it can help alleviate negative emotions and promote adherence to medication in patients with rheumatoid arthritis. Specifically, a 12-month telemedicine intervention should be considered for diabetic patients to achieve better management of their condition.

References:

Yue Ma, Chongbo Zhao, Yan Zhao, Jiahong Lu, Hong Jiang, Yanpei Cao, Yafang Xu. "Telemedicine Application in Patients with Chronic Disease: A Systematic Review and Meta-Analysis" (2022) BMC Medical Informatics and Decision Making. Accessed October 20, 2024. https://bmcmedinformdecismak.biomedcentral.com/articles/10.1186/s12911-022-01845-2#Fig6

- See original paper for additional references.

Antimicrobial Resistance and Climate Change

Revised by Sky Phisuthikul

Globally, antimicrobial resistance (AMR) and climate change (CC) are two of the top health emergencies and priorities. Here, we provide an overview of the current knowledge about the relationship between AMR and CC. The studies emphasize the need for applying a systemic approach to planetary health. Firstly, CC increasingly brings humans and animals into contact, leading to outbreaks of zoonotic and vector-borne diseases with pandemic potential. Although it is well-established that frequent antimicrobial use is a main drivers of AMR, the COVID-19 pandemic is exacerbating the current scenario, influencing antibiotic use, personal protective equipment, and biocides. This results in higher concentrations of contaminants (e.g., microplastics) in natural water bodies, which cannot be completely removed and sustain the AMR spread. Our overview underlines the lack of studies on the direct relationship between AMR and CC and encourages further research to investigate the various aspects involved and their effects on human health.

INTRODUCTION

Antimicrobial resistance (AMR) is one of the most pressing global health challenges. While antimicrobial use exerts an ecological pressure on bacteria, poor infection prevention and control (IPC) practices support their spread. Bacteria could acquire resistance mechanisms, severely limiting treatments and sustaining the spread of such multidrug resistant (MDR) organisms. Hence, the prudent use of antimicrobials, and an improvement of IPC are needed. Climate change (CC) is also affecting human health through the following direct effects: rising temperatures, increased number of heat-related mortality and morbidity, and more common occurrences of high-intensity storms. Some indirect effects include: human health, environmental conditions, food and nutritional security, and shifting ecosystems. These result in higher risk of foodborne, water borne and vector-borne diseases, and the potential increase in negative mental health outcomes. The high occurrence of diseases described could further increase the improper use of antimicrobials. To reduce the burden of infectious diseases and AMR, the protection of humans, animals and environment is necessary, in a perspective defined by the so-called One Health approach.

The resulting pandemic has only further underlined the need for antimicrobial stewardship to prevent AMR. The pandemic has made the AMR crisis worse due to increasing antibiotic usage and drug-resistant secondary infections in hospitals. It is also necessary to understand that these two issues are not uniformly distributed. There are greater impacts on low-medium income countries, and individuals with pre-existing health conditions or close connections to local environments often experience higher burdens from CC.

Current evidence regarding the potential link between AMR and CC is still lacking, suggesting the need for ad-hoc surveillance and multidisciplinary research. To sum up what has been done so far, we provide an overview of the current knowledge we understand. To do so, we utilized PubMed and Web of Science databases for articles published from inception to 1 September 2022, using the following combination of terms: “Climate change” AND (“Antimicrobial resistance” OR “Antibiotic resistance”). After removing duplicates, 346 articles were obtained from literature databases and additional studies were identified from their reference lists. For study selection, we did not apply specific criteria in terms of publication year, study design, settings, target of study and/or specific aspects of the relationship under consideration. Due to the general aim of this overview, the studies were selected if they discussed the potential relationship between climate change and antimicrobial resistance.

Need for Global Solutions Against AMR

The main contributing factor is the high consumption of antibiotics. Low and middle-income countries are seeing rates of antibiotic usage, hospitalization and prevalence of healthcare associated infections (HAIs) increase. The causes of AMR mainly arise as a consequence of mutations in bacteria and the selection pressure from antibiotics that provide a competitive advantage for mutated strains. The emergence and spread of MDR pathogens continue to threaten the ability to deal with many of the most common infections. Mortality for AMR is also rising in developing countries, especially for new-borns with maternal-acquired neonatal infections.

AMR is associated with longer states of illness, higher mortality rates, increased costs, and ineffective antibiotic treatments. The economic burden of AMR is also aggravated by the inability of performing surgeries or therapies (i.e., chemotherapy) in absence of effective antibiotics. The global and rapid spread of multi- and pan-resistant bacteria (also known as "superbugs") is especially alarming as they are not treatable with existing antibiotics.

Moreover, in many low and middle-income countries, people do not have full access to novel and more effective antibiotics and so they often resort to using common antibiotics without prescription. This situation is also increased by the uncontrolled antibiotic use in non-clinical fields (e.g., agriculture, aquaculture and intensive farming), accounting for a volume four-times higher than that observed in humans.

In this scenario, several comprehensive strategies should be implemented to control AMR such as surveillance of antibiotic use, detection of resistance in human beings and animals, awareness campaigns on the correct use of antibiotic, and antibiotic stewardship programs in healthcare settings. Cooperation between prescribers, dispensers and patients will also be necessary. Actions from single countries may also have potential effects on others and improve the situation globally; for this reason, global and national contributions are urgently required today more than ever.

AMR and CC: One Health Approach

Although AMR is a natural phenomenon, the main drivers of its development and spread are man-made. Findings from studies regarding animal-to-human transfer of resistance genes confirm the need of international actions tackling AMR across multiple sectors.

The most logical attack is through the One Health approach, focusing on the simultaneous protection of humans, animals and the environment. Early identification of infectious disease related to CC is crucial to manage "outbreaks" in all settings. Additionally, the high use of antimicrobials in livestock farms and agriculture and the increase in AMR necessitate a strict collaboration between veterinarians and clinicians. For example, mass vaccination of animals—both feasible and cost-effective—could help reducing livestock-mediated zoonoses.

In the same way, intersectoral strategies may be effective also against the climate crisis. The majority of studies has thus far been focused on one of these dimensions. In general, evidence of their relationship is lacking, suggesting the need for interdisciplinary research with the One Health approach. Thus, a deep investigation of the potential relationship between AMR and CC should be encouraged to implement the synergy between human, animal and environmental health partners.

Two Intertwined Global Challenges

Relationships between CC and AMR at Human, Animal and Environmental Levels

The effects of CC on human health is worsening with time, as well as its impact on Public Health that affects all the physical, natural, social and behavioural dimensions. This is very similar to that observed for AMR. Factors that potentially contribute to the relationship between CC and AMR are summarized in Figure 1. Understanding how AMR evolved alongside CC can provide insights to better design future efforts and for this reason, it would be necessary to better understand: (i) the relationship between CC and AMR with a focus on humans, animals and the environment; (ii) current strategies and future interdisciplinary research on their interactions; (iii) the impact of financing, political advocacy and global actions; and (iv) the role of the COVID-19 pandemic in this alarming scenario.

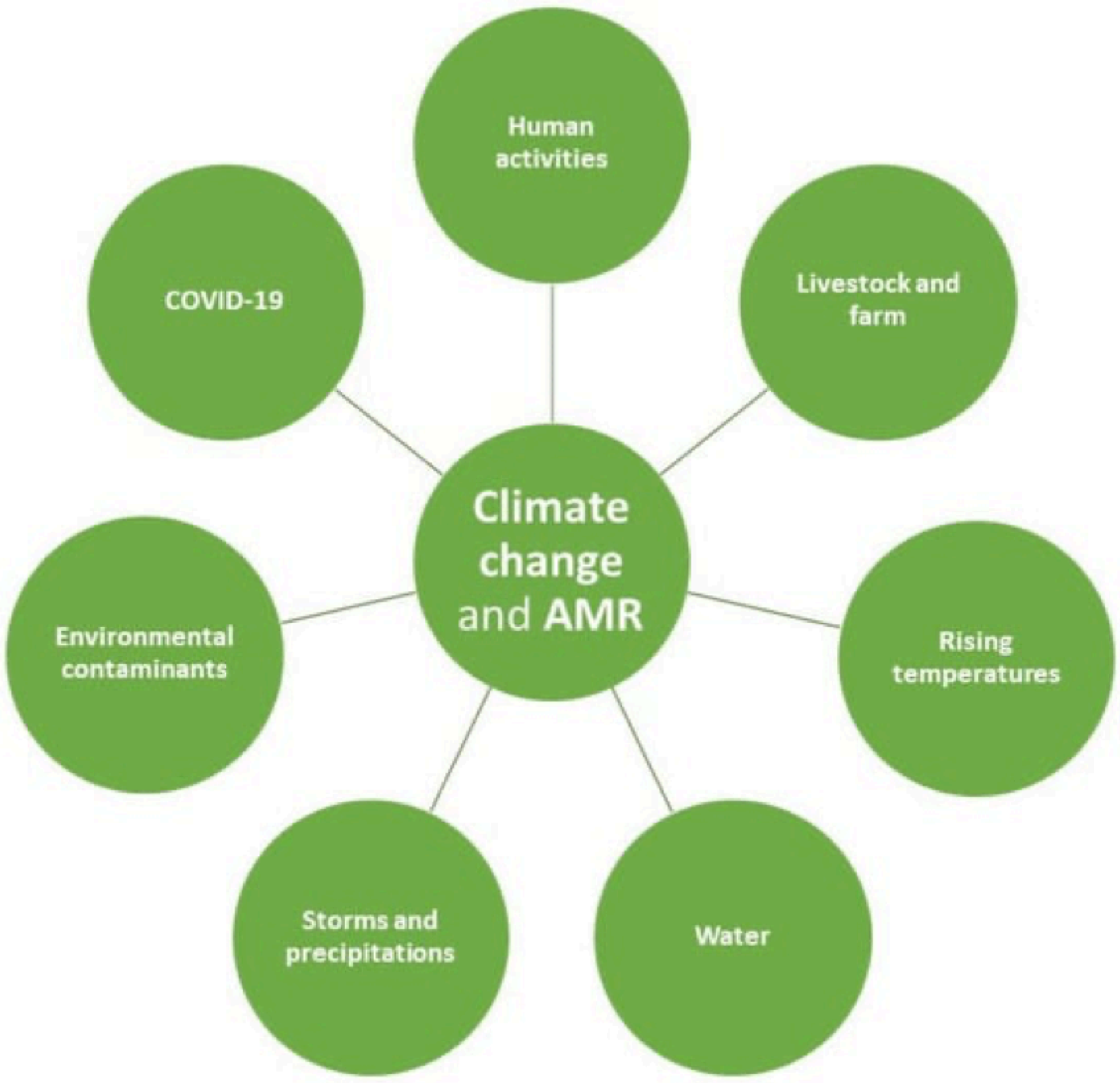


Figure 1: The main factors involved in the relationship between climate change and antimicrobial resistance.

While temperatures rise as a consequence of CC, AMR is increasing in humans, animals, plants and the environment. Increasingly higher temperatures are associated with increased bacterial growth rates and horizontal gene transfer. In line with this, the climate crisis may also be responsible for the spread of new and re-emerging pathogens which could harbour new resistance mechanisms. Heat and humidity are considered as two important factors involved in its spread.

Similarly, vector-borne infections typical of tropical climates are slowly migrating towards countries with warmer temperatures, even in winter months. A seasonality has been documented for influenza and some bacterial infections.

It has also been demonstrated that warmer climates might affect heavy metals or biocides concentrations in soil and water, as well as their bacteria uptake, triggering AMR by co-resistance mechanisms. Stated by Kusi, healthcare facilities, wastewater, agricultural settings, and foods are major vehicles of AMR in the mentioned concentrations. Although CC could be considered an additional determinant of AMR in the aquatic environment, its causal effect should be considered with caution.

Rising temperatures are closely linked with flooding, displacement and overcrowding caused by storms and precipitations. These lead to an increase in waterborne infections, which result in increased pressure on health systems and a collapse of sanitation infrastructures. Several waterborne diseases—such as cholera outbreaks in Haiti and Nepal after the earthquakes—are well-documented.

In addition, extreme weather events could lead to drought that determine higher risk of acquiring antibiotic-resistant enteric pathogens. Furthermore, ensuring the global high quality of water requires addressing. However, further efforts are needed to improve the quality of water and contain the spread of common infections. Findings described above are summarized in Table 1.

Table 1. Summary of the relationship between climate change and infections.

Table 1. Summary of the relationship between climate change and infections.

Microorganisms	Role of Climate Change	Disease
Campylobacter spp. and *Salmonella* spp.	Rising temperatures in water system contributes to better survival of these microorganisms [31,58,59,82]	Waterborne and foodborne diseases
Vibrio cholerae	Rising temperatures led to natural disasters, determining better conditions for the microorganism survival [59,116]	Waterborne diseases (Cholera)
Candida auris	Gained thermotolerance and salinity tolerance on the wetland ecosystem [31,76,77]	Fungal infection (Candidiasis)
Plasmodium falciparum	Rising temperatures and humidity contributes to increased transmissibility [56,78,80]	Vector-borne disease (Malaria)
Zika, Chikungunya and Dengue viruses, *Tripanosoma cruzi*	Warmer temperatures led to rising spread of vectors, even in winter months [83]	Vector-borne diseases (Zika, Chikungunya, Dengue and Chagas diseases)
Pseudomonas aeruginosa, *Klebsiella pneumoniae*, *Escherichia coli*, and *Staphylococcus aureus*	Warm-season changes in temperature contributes to their optimal growth conditions at 32–36 °C [101]	Gram negative infections (especially in healthcare settings)
SARS-CoV-2	Increased aridity and prolonged droughts led to bats migration and increased viral transmission [32,33]	COVID-19 disease

Storms and precipitations can also damage wastewater- a reservoir for antibiotic-resistance genes (ARGs) and sewage infrastructure, increasing the risks of floodwater pollution. AMR bacteria and ARGs are not totally removed during wastewater treatment, being discharged into the environment. The characterization of the environmental resistome allows us to quantify and assess ARGs, with sewage and wastewater treatment plants (WWTPs) as the main objects of international monitoring studies. Municipal wastewater could be considered as a major vital source for ARGs, suggesting an alarming antibiotic use in the community. Moreover, the abundance of certain ARGs reflects the abuse of these antibiotics for the treatment of livestock and aquaculture.

In this scenario, microplastics are defined as conventional plastic with dimension <5 mm, accumulated in landfills or in the natural environment- particularly in waters, soils and air [136]- that fragment rather than decompose. They have been proposed as hotspots of horizontal gene transfer and crucial factors for the evolution of environmental microbial. For this reason, metagenomic sequencing methods could assess the effects of microplastics on the spread of ARGs in several environmental settings, including waters, soils and air. With respect to soil, pollutants have been shown to increase AMR levels.

It is therefore plausible to state that the impacts of CC will result in an increased use of antimicrobials. As a result of heat stress, for instance, poultries are overtreated with antibiotics. Industrial animal farming also contributes to the rise of AMR by expanding deforestation, which makes human contact with wild animals that are carriers of zoonotic diseases closer. Without shifts in global meat consumption, agriculture will consume the global carbon budget needed for keeping global temperature rises under 2 °C by 2050. Urgent efforts are also required for the productive industrial activity of aquaculture—defined as "the farming of aquatic organisms including fish, mollusks, crustaceans, and aquatic plants"—which involves antibiotic use for treatment and prophylaxis. In Mediterranean aquaculture facilities, the overuse of antibiotics leads to their higher levels in the surrounding sediments and water column. As reported by several studies, aquaculture is a hotspot for ARGs. With respect to the relationship between AMR and CC, antibiotic-related modifications in bacterial cells are similar to those caused by increased temperatures. The AMR indices of aquaculture are related with those of human clinical bacteria, temperature and climate vulnerability of countries. Since further increase in AMR may be experienced, innovative and sustainable solutions are needed through the One Health approach.

Current Strategies and Future Research

Current evidence about the effects of CC on AMR should be translated into a common vocabulary and a fruitful dialogue between political leaders, policymakers, media, and the general public. With respect to the public, climate activists are used to shock people by exaggerating the problem; it is unlikely this kind of approach could sustain behavioural changes. Instead, people should be guided in the fight against AMR and CC by reducing the prescriptions of unnecessary antibiotics, involving clinicians, who need resources to reduce unnecessary prescribing. Since the current evidence is relatively scarce, multidisciplinary research is encouraged to develop epidemiological studies. The application of artificial intelligence (AI) and machine learning (ML) could provide a different point of view from which the well-known problem can be tackled. Nowadays, the main efforts in the field of CC and AMR are related to forecasting and surveillance: the first one is necessary for deploying prophylactic measures and limiting the spread of diseases; the second one for monitoring their spread. Disease surveillance should be implemented in the context of Big Data. Therefore, both direct and indirect effects of climate crisis on AMR should be deeply investigated using multidisciplinary and innovative approaches.

Economic and Political Interventions

The psychological distance represents a key barrier to people's engagement with global problems, leading to inaccurate perceptions of the consequences on human health. Policymakers need to develop novel ways to make the issue closer to reality. A growing interest in the establishment of an Intergovernmental Panel on Climate Change (IPCC) for AMR is well-known. 117 countries have AMR National Action Plans approved by their governments and are aligned with the Global Action Plan for AMR. However, global challenges, such as CC may threaten current AMR mitigation efforts. The Global Leaders Group on Antimicrobial Resistance underlines the need for a more high-level political advocacy to ensure AMR's inclusion in climate crisis discussions. Additional financing is also needed to incorporate linkages between AMR and CC into existing One Health strategies and initiatives. Thus, a comparison has been proposed between the Paris Climate Agreement and the existing global AMR efforts.

First, AMR needs a unifying target to benchmark global progress. It is also necessary to focus on social, collective and economic transformation instead of emphasizing individual behaviours. Escalating commitments through national AMR action plans is required to improve current efforts is also another necessary measure. Multi-stake-holders forum on AMR could be useful for ensuring an ongoing and inclusive dialogue, as well as for shaping equitable goals and actions. Moreover, ongoing AMR action would be best informed by a global scientific stock taking every 5 years. Lastly, an international legal framework could generate progress on AMR by creating a sustainable system with the active contribution of countries. Designing the trajectory of AMR changes is complex, due to complexities in cost estimation, which includes: specific pathogen prevalence; AMR mechanisms; the level of transmissibility and the burden of infections; health consequences (e.g., chronic diseases and longer hospital stays); and the available alternative treatments. An approach to anticipate the possible risk is "scenario planning"—defined as a type of foresight method that enables exploration of alternative future worlds. Specifically, experts from multiple sectors involved in the study conducted by Lambraki and colleagues construct three alternative futures for two promising interventions: (i) taxation of antimicrobials at point of sale, and (ii) infection prevention measures. The infection prevention measures are considered as key strategies for containing AMR in 2050, contributing for the achievement of the Sustainable Development Goals (SDGs). In this way, it could be possible to tackle inequities underpinning AMR and CC, with the perspective of a holistic approach.

COVID-19 Impacts

Countries and health systems continue to deal with the health and socio-economic effects of the COVID-19 pandemic. The economic losses associated with climate crisis determine increased pressure on economies already modified by synergistic effects of the COVID-19 pandemic. For instance, the coexistence of outbreak infections and COVID-19 pandemic has a negative impact on the healthcare system. Similarly, food security and availability are affected by CC and the COVID-19 pandemic. It has been reported that COVID-19 pandemic has reduced financing available for climate action. Urgent action is needed to strengthen health-system resilience. With the COVID-19 pandemic, an increased number of hospital-acquired infections was evident, with higher risk for AMR. Although COVID-19 is a viral infection, it could clinically progress to bacterial pneumonia, requiring antibiotic administration. Along with antibiotics, a broad spectrum of pharmaceutical products used to address the spread of the virus can be collectively referred to Pharmaceutical and Personal Care Products (PPCPs). Although the WHO have developed guidelines for the PPCP usage, lack of knowledge and the COVID-19-related panic can lead to adverse effect on health.

As stated above, the contamination of waters with the so-called "emerging contaminants" (e.g., biocides, disinfectants, pharmaceuticals, hormonal drugs and cosmetic products) was a pre-existing problem. The pandemic did nothing more than aggravate this problem. Similarly, the overuse of plastics in the COVID-19 era (e.g., facial and surgical mask) determines the build-up of microplastics, a stable substrate for microbes and ARG exchange. Urgent interventions are thus needed to evaluate the impact of COVID-19 on AMR and the climate crisis, and to contain the consequently harmful effects. The promotion of Public Health strategies to reduce the spread of AMR is therefore recommended.

DISCUSSION

CC and AMR are two of the greatest threats currently facing the world, both being exacerbated by, and can be mitigated with, human actions. The burden of infectious disease could be still reduced focusing on One Health strategies. Simultaneously, climate crisis has an impact by determining higher risk of emerging diseases and AMR. Future generations will not enjoy the benefits of carbon and antibiotic consumption. However, the trajectories of CC and AMR are strongly dependent on population levels and densities. Alongside with natural CC (e.g., in water and ecosystems) involved in the potential increased spread of AMR, there is the urgent need for evaluating antimicrobial stewardship principles to prevent AMR during the COVID-19 pandemic. Proper resources and education should be improved for the entire population. Successful public health interventions are based on cooperation; there is a need to apply a systemic approach to the health of the planet. Further efforts are needed to investigate the relationship between environmental change and human health and to evaluate the political and socio-economic systems underpinning those effects.

CONCLUSION

The complex commonalities between AMR and CC should be deeply investigated in a One Health perspective. Our overview on the current knowledge about the relationship between AMR and CC pointed out the need for further research to deeply investigate these two intertwined global challenges. It should be clear that CC increasingly brings humans and animals into contact, leading to outbreaks of zoonotic and vector-borne diseases with pandemic potential. Moreover, it is well-established that antimicrobial use in human, animal and environmental sectors is one of the main drivers of AMR. The COVID-19 pandemic is exacerbating the current scenario, influencing the use of antibiotics, personal protective equipment and biocides, resulting in higher concentrations of contaminants in natural water bodies. For this reason, contaminants cannot be completely removed from wastewater treatment plants, sustaining the AMR spread. Thus, a planetary health approach could offer potential solutions to commonly tackle these important public health issues.

REFERENCES

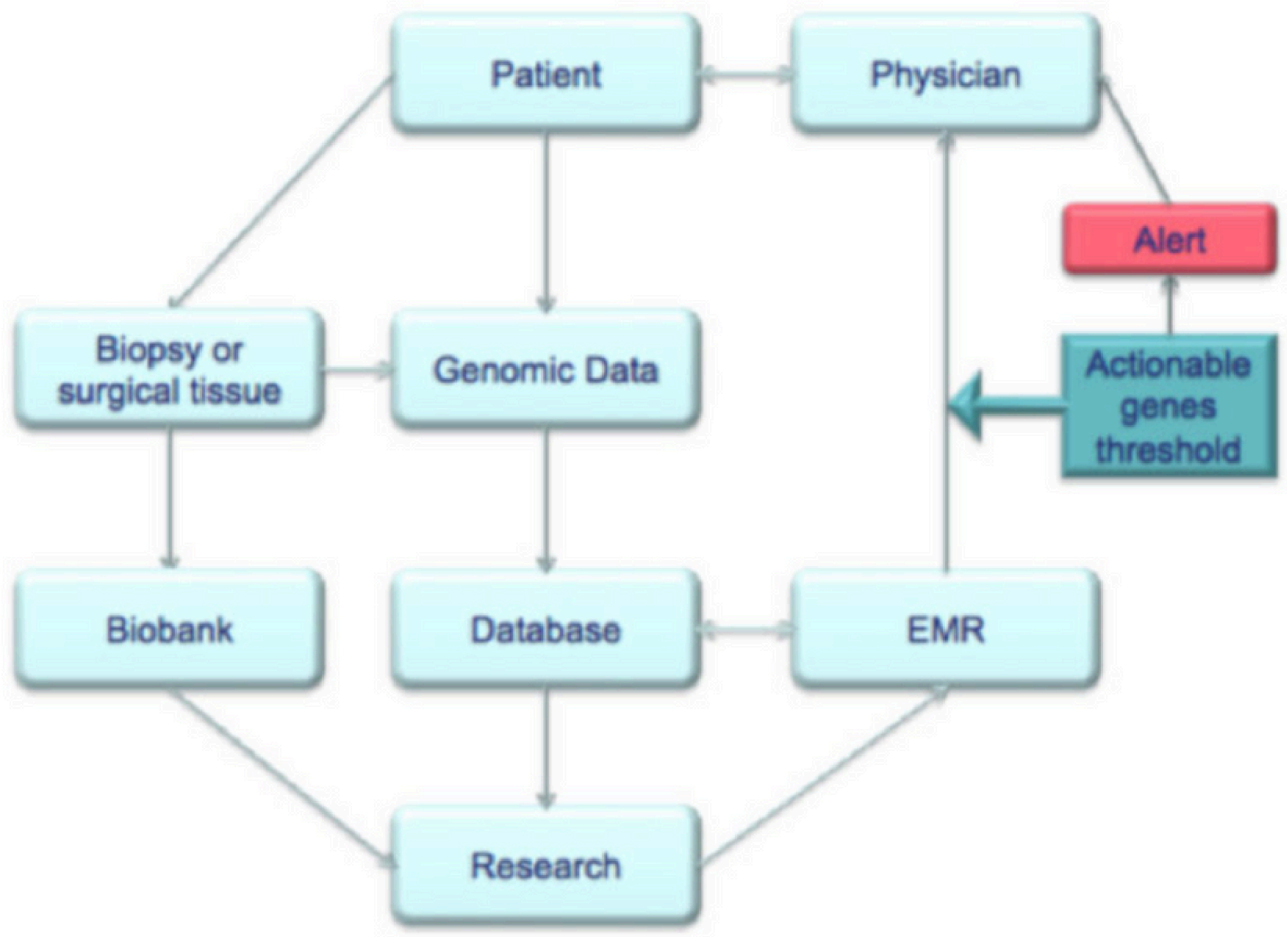
Roberta Magnano San Lio, Giuliana Favara, Andrea Maugeri, Martina Barchitta, Antonella Agodi. “How Antimicrocbial Resistance is Linked to Climate Change: An Overview of Two Intertwined Global Challenges” (2023) MDPI. https://www.mdpi.com/1660-4601/20/3/1681

- See original paper for any additional references

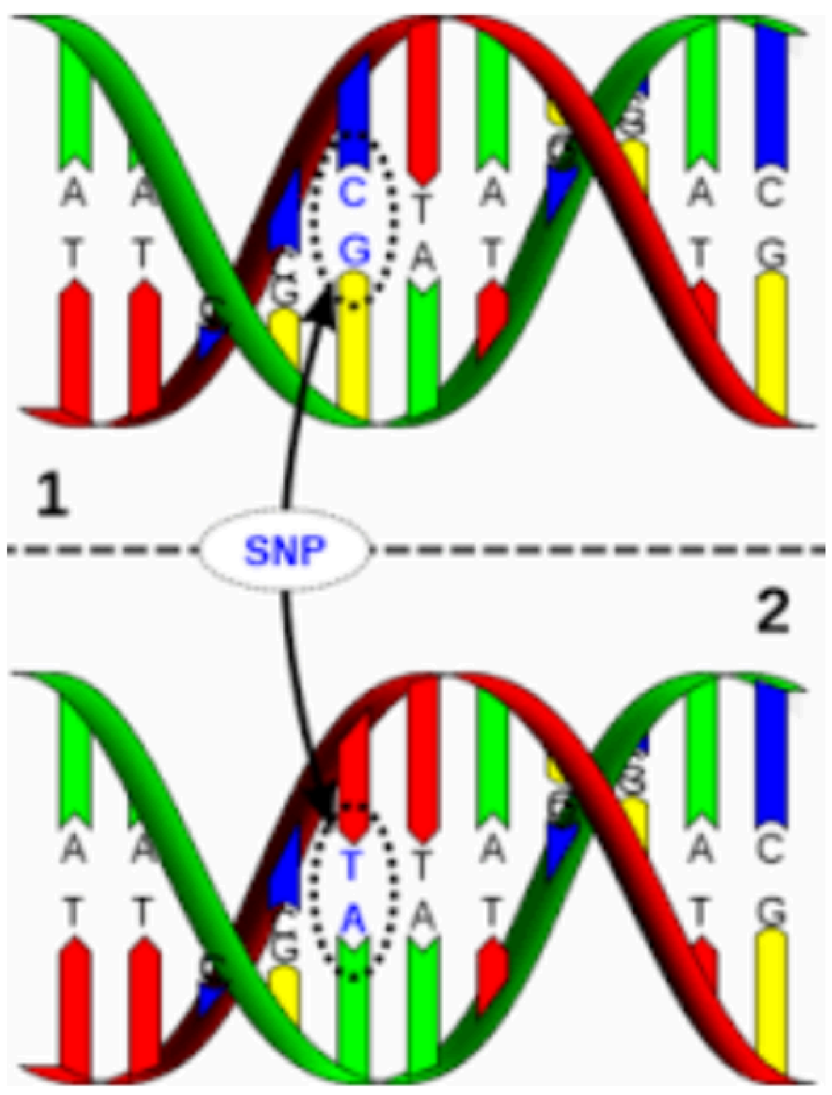
The Role of Genomics and Biotechnology in Personalized Medicine

Revised by Nathan Zhuang

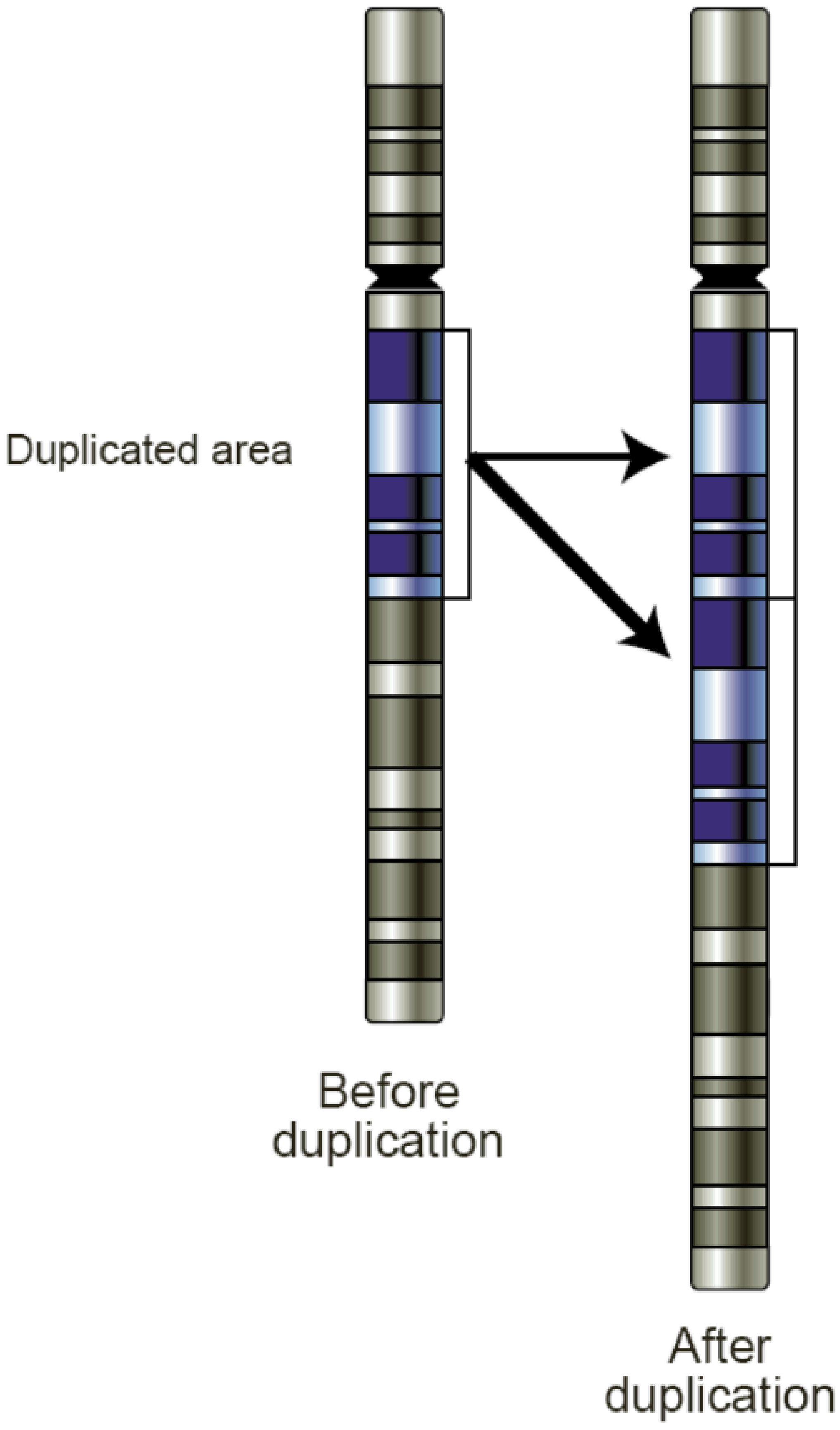
In recent years, the field of Genomics –the act of customizing treatment for each individual patient– has advanced at an alarming rate. The goal of Genomics is to improve diagnosis treatment based on personal requirements, thus minimizing both side effects and cost. Genomics has allowed the rise of Personalized Genomic Medicine and Surgery (PGMS). The reason that this is significant is due to the help it gives in classifying diseases and finding effective treatments based on genetic variations.



The foundation of PGMS was laid through research projects, beginning with the Human Genome Project in 2003. This international initiative successfully mapped the entire human genome, providing a map of human genetic structure. The International HapMap Project from 2002-2009 followed, identifying genetic variations, including **single nucleotide polymorphisms** (SNPs) and **copy number variations** (CNVs), that contribute to disease susceptibility. Finally, the 1000 Genomes Project in 2008 cataloged genetic variants to enhance our understanding of disease mechanisms and treatment responses. Together, these efforts have transformed genetic insights into actionable medical tools.



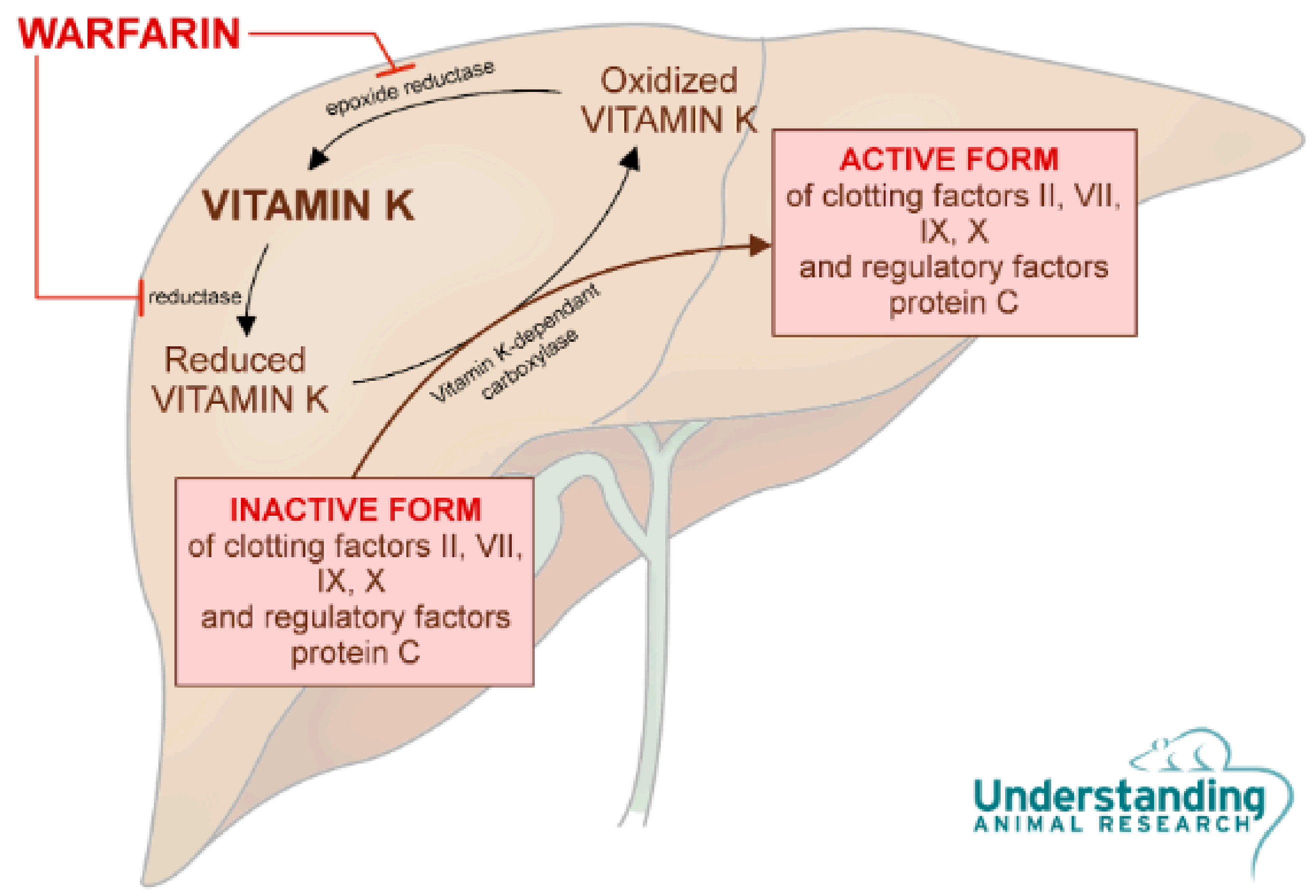
Genetic profiling has enabled the identification of individuals at higher risk for specific diseases. Variants such as SNPs and CNVs play a critical role in this process. For instance, SNPs in the apolipoprotein E (APOE) gene are directly linked to Alzheimer's disease. CNVs have been associated with human immunodeficiency virus (HIV) resistance and autoimmune disorders.



A notable example is the Breast Cancer Type 1 and Breast Cancer Type 2 gene mutations, which significantly increase the risk of breast and ovarian cancer. Early detection strategies, such as regular mammograms and colonoscopies, are now tailored to individuals with these mutations, offering proactive approaches to disease prevention.

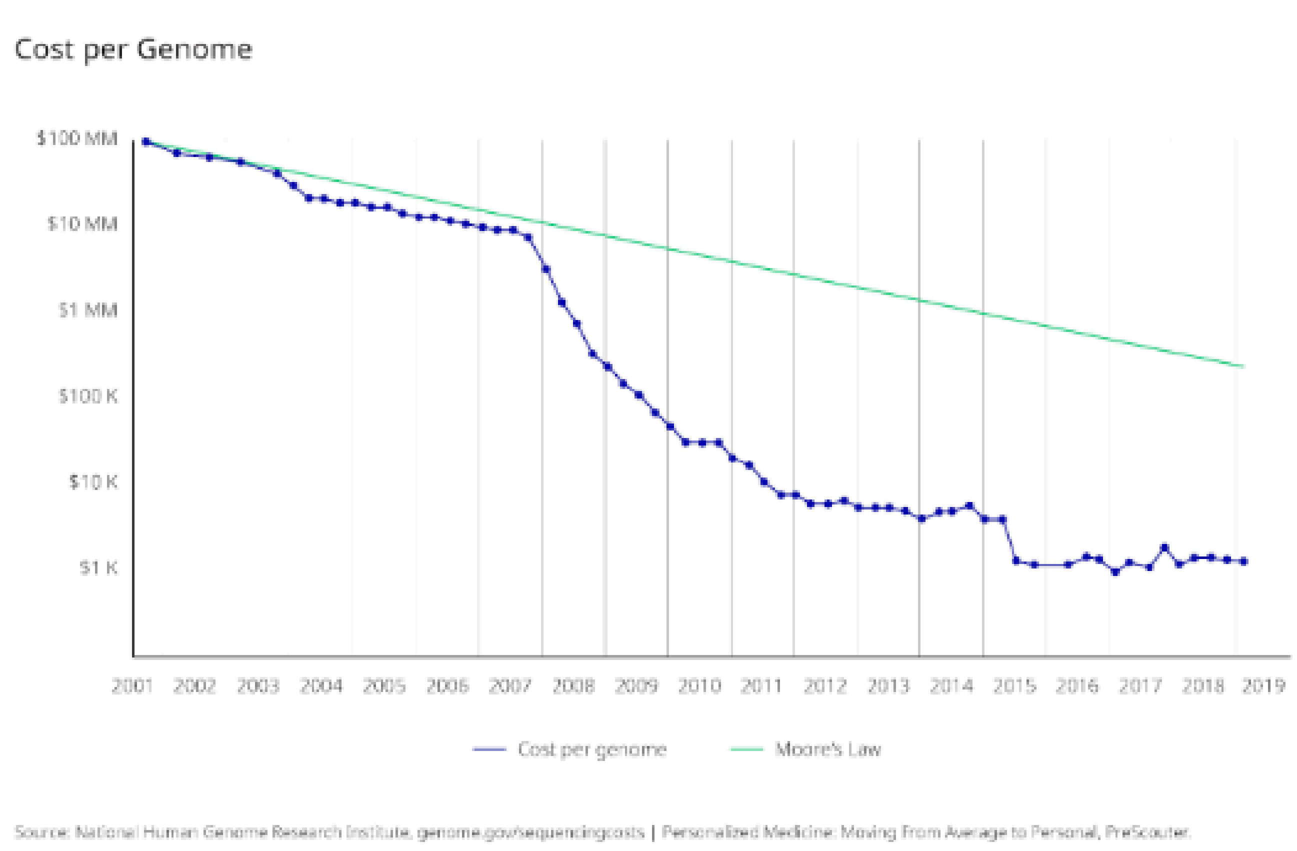
Pharmacogenomics, a cornerstone of PGMS, studies how genetic variations influence drug metabolism. This knowledge has transformed medication management, ensuring optimal efficacy and minimizing side effects.

For example, the anticoagulant warfarin, namely, a drug to prevent clotting in the blood, requires precise dosing due to genetic variations in the CYP2C9 and VKORC1 enzymes, which affect drug metabolism and bleeding risk. Similarly, genetic testing for CYP2D6 helps determine the effectiveness of tamoxifen, a common breast cancer treatment. Recognizing the significance of these genetic factors, the FDA now recommends genetic testing for various medications.



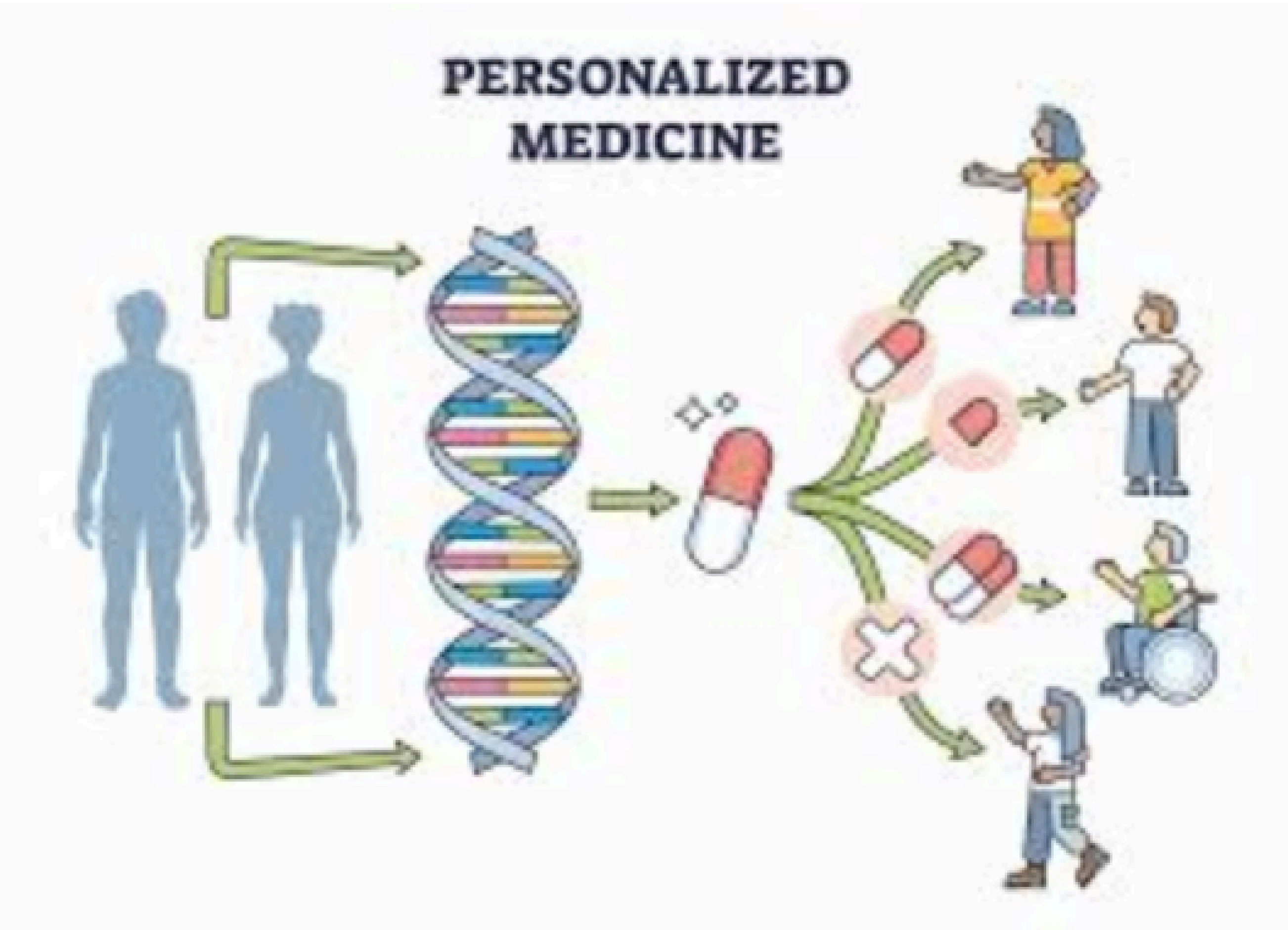
Cancer treatment has greatly benefited from identifying molecular biomarkers that guide targeted therapies. A prominent example is the Receptor tyrosine-protein kinase (HER2) biomarker in certain breast and gastric cancers. Patients with HER2-positive tumours benefit from therapies like trastuzumab (Herceptin), which specifically targets this biomarker, improving survival rates and treatment outcomes. Without Genomics finding this specific genome would be nearly impossible to determine.

Despite its transformative potential, PGMS faces significant hurdles. One major challenge is the cost of genome sequencing, which, although decreasing, remains prohibitively expensive for widespread use (costing around 2000 USD per extensive test). Another issue is the complexity of genetic variants, as many factors influencing disease and treatment responses require further research to translate into clinical practice.



The future of PGMS lies in combining genomic data with other medical disciplines. The updated Genomic, Imaging, Function, and Therapy Model (GIFT) envisions a different approach, where genomic insights inform clinical decision-making alongside imaging and functional analyses. As technology advances, genomic information may become a routine part of medical records, empowering healthcare providers to deliver personalized care.

Personalized Genomic Medicine and Surgery represent a huge shift in healthcare. By using genetic information, it



not only enhances our ability to diagnose and treat diseases but also paves the way for preventive strategies that improve overall health outcomes. As research progresses, the cost of PGMS may become more accessible. Integration of PGMS into mainstream medicine holds the promise of a healthier and more precise future for all.

REFERENCES

Brunicardi, F. C., Gibbs, R. A., Wheeler, D. A., Nemunaitis, J., Fisher, W., Goss, J., & Chen, C. (2011). Overview of the development of personalized genomic medicine and surgery. World Journal of Surgery, 35(8), 1693–1699. https://doi.org/10.1007/s00268-011-1056-0

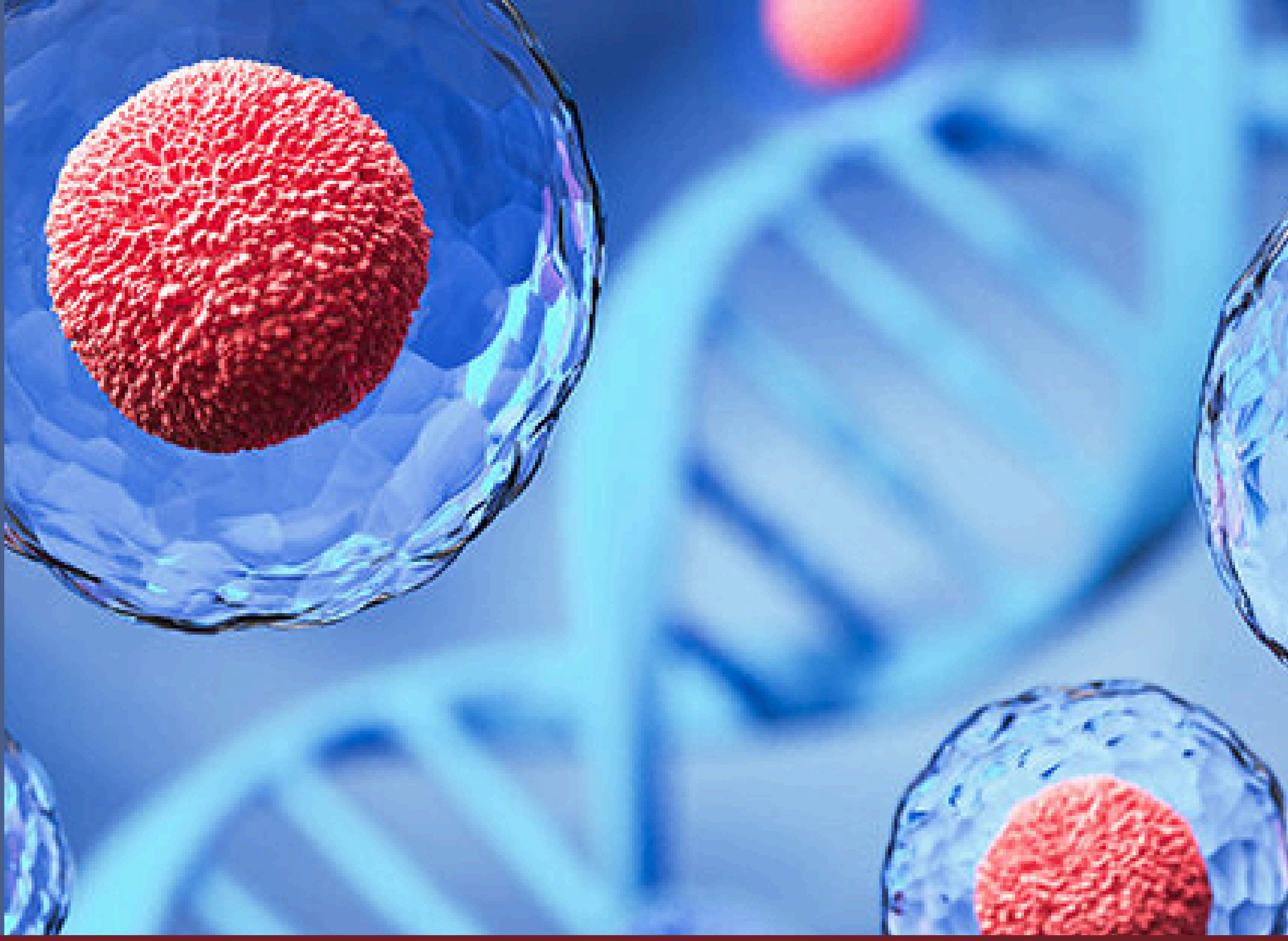
- See the original paper for more references

Image Sources:

- https://mkainsights.com/insights/biotech-pharma-healthcare/what-is-genomics/
- https://www.cellr4.org/article/856
- https://isogg.org/wiki/Single-nucleotide_polymorphism
- https://en.wikipedia.org/wiki/Copy_number_variation
- https://www.animalresearch.info/en/drug-development/drug-prescriptions/worfarin-sodium-anticoagulant/
- https://www.oliverwyman.com/our-expertise/perspectives/health/2020/feb/personalized-medicine-is-about-to-go-mainstream-with-big-implica.html
- https://www.medznat.ru/en/practice/medical-billing/precision-and-personalized-medicine-unlocking-the

Regenerative Medicine

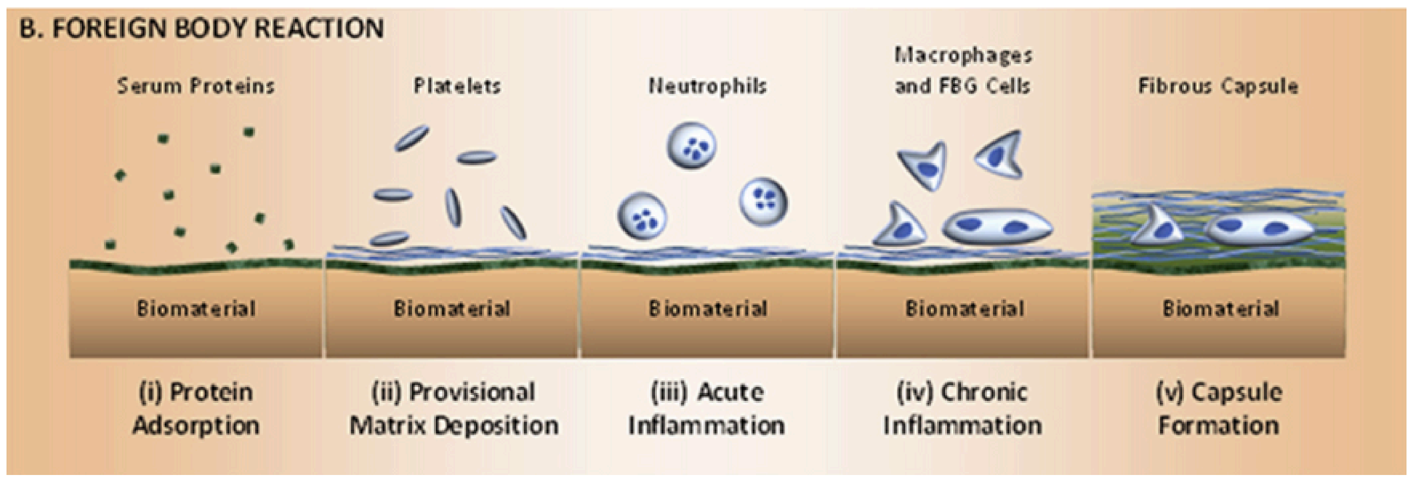
Revised by Jessica Lu



Regenerative medicine is an innovative field of medicine that aims to rejuvenate and replace damaged and diseased tissue. This encompasses tissue engineering, drug delivery, immunomodulation, and genetic engineering. Scientists hope to build off the basis of the human body's natural growth to replicate environments where targeted regeneration can occur. For example: wound healing processes demonstrate the natural regenerative potential of cells, platelets and neutrophils collected at the wound site release growth factors and chemoattractants. These trigger the arrival of white blood cells (macrophages, lymphocytes), fibroblasts, and endothelial cells. These cells remove damaged tissue and supply the wound site with new connective tissue, termed collagenous granulation tissue.

Many significant factors affect the success of regenerative therapy. For example, whether the tissue is sourced from the patient (autologous) or a donor (allogeneic). Tissue from the patient is preferred due to the possibilities of immune rejection and iatrogenic infection with donor tissue; iatrogenesis refers to the side effects and risks of medical intervention. Furthermore, innate and adaptive immunity create challenges for therapies that involve bringing in biomaterials from outside the body. Innate immunity involves a non-specific inflammatory response after a substance is recognized as foreign, known as allorecognition. The immune response includes phagocytosis, apoptosis, and opsonization. Adaptive immunity is a specific response that provides long-term immunological memory. It includes the activation of natural killer cells (e.g. T cells, B cells). Other factors to be considered are whether to use stem cells or pre-specialized cells, and whether or not to use like-for-like cell types to replace damaged cells.

Furthermore, stem cells can exhibit either *multipotency* or *pluripotency*, either being able to differentiate certain cell types or differentiate into any of the cells in the body, respectively. The *in vitro* (meaning outside a living organism), controlled differentiation of pluripotent stem cells (iPSCs) has allowed for a greater variety of cells to be created and used for therapeutic purposes. Coincidently, *in vitro* differentiation comes with the risk of tumorigenicity, where stem cells have the tendency and capability to form tumours. This can affect many regenerative therapies, which require implanted biomaterials to interact with the surrounding environment, to restore biological function. These biomaterials will also often invoke a host immune response (i.e. foreign-body reaction) that can negatively impact integration and performance. Figure B illustrates the process of fibrous capsule formation resulting from an implanted biomaterial.



The type and severity of an immune response is dependent upon several factors, including the size of the biomaterial and the location of the implant. Accordingly, researchers have begun to develop immune evasive therapies, such as using hydrophilic polymer coatings to minimize the immune response, and pharmacological or cell-based immunosuppression to inhibit T-cell activity.

Developments in in vivo (inside a living organism) imaging, such as magnetic resonance imaging (MRI) and computed tomography (CT), are crucial for understanding the constraints and effectiveness of regeneration during clinical trials. For example, computed tomography (CT) has been used to monitor bone ingrowth into an implanted scaffold, or temporary structure. The table below provides examples of successful clinical trials during the 2018-2019 interval.

Indication	**Trial Details**	**Regenerative Therapy**	**Reference**
Macular degeneration	- Phase I - 2 patients	Human iPSC derived retinal pigment epithelium delivered on a PET membrane.	L. Da Cruz *et al. Nat. Biotechnol.* **2018** *(70)*
Thoracic spinal cord injury	- Phase I - 4 patients	Human NSCs (NSI-566) injected locally using a stereotactic floating cannula.	E. Curtis *et al. Cell Stem Cell* **2018** *(71)*
Ischemic stroke	- Phase I - 9 patients	Intra-carotid artery transfusion of autologous $CD34^+$ cells in the infarct area.	P.-H. Sung *et al. Am. J. Transl. Res.* **2018** *(94)*
Compensated liver cirrhosis	- Phase I - 9 patients	Peripheral infusion of matured autologous monocyte-derived macrophages.	F. Moroni *et al. Nat. Med.* **2019** *(95)*

The technical risks associated with regenerative therapies include harmful transformation, disease transmission, immune rejection, and toxicity. Additional risks can arise during storage, delivery, surgery, and other handling processes. The article suggests increased automation, closed systems that limit contamination, and genetic divergence-reducing culture protocols to increase the reliability and reproducibility of regenerative therapies. The field of regenerative medicine continues to grow and expand, working to create reproducible, cost-effective, and safe therapies for widespread clinical use.

REFERENCES

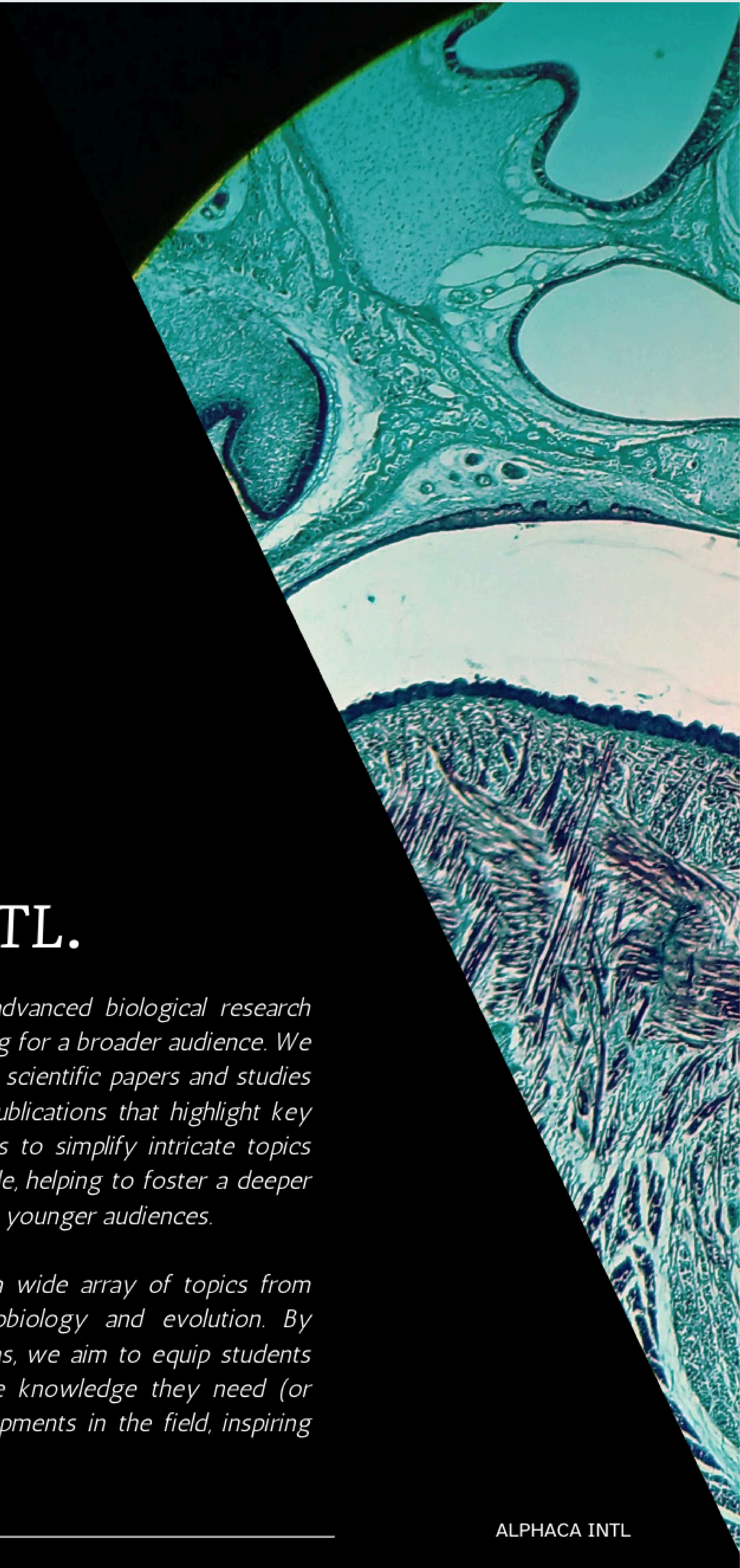
Armstrong, J. P. K., Keane, T. J., Roques, A. C., Patrick, P. S., et al. (2020, December 2). A blueprint for translational regenerative medicine. Science translational medicine. https://pmc.ncbi.nlm.nih.gov/articles/PMC7610850/

- See the original paper for more references

Petrosyan, A., Martins, P. N., Solez, K., Uygun, B. E., Gorantla, V. S., & Orlando, G. (2022, November 25). Regenerative Medicine Applications: An overview of clinical trials. Frontiers in bioengineering and biotechnology. https://pmc.ncbi.nlm.nih.gov/articles/PMC9732032/

Seladi-Schulman, J. (2019, August 19). In vivo vs. in vitro: Definition, examples, and more. Healthline. https://www.healthline.com/health/in-vivo-vs-in-vitro

Wang, Z. (2023, July 19). Assessing tumorigenicity in stem cell-derived therapeutic products: A critical step in safeguarding regenerative medicine. Bioengineering (Basel, Switzerland). https://pmc.ncbi.nlm.nih.gov/articles/PMC10376867/



ALPHACA INTL.

We are committed to making advanced biological research more understandable and engaging for a broader audience. We focus on breaking down complex scientific papers and studies into clear, easy-to-understand publications that highlight key findings and ideas. Our mission is to simplify intricate topics and make them more approachable, helping to foster a deeper interest in the life sciences among younger audiences.

Focused on biology, we cover a wide array of topics from genetics and ecology to microbiology and evolution. By providing well-crafted publications, we aim to equip students and science enthusiasts with the knowledge they need (or want) to grasp the latest developments in the field, inspiring curiosity in future generations.