The Advancement of Medical Biotechnology in Developing Countries: Economic Opportunities and Challenges

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Abstract. Starting from decades ago, medical biotechnology has revolutionized the healthcare industry by offering new hopes for previously untreatable diseases and improving overall health outcomes. To explore the advancements in medical biotechnology, this research essay begins by introducing several examples of medical biotechnologies that are currently in progress of advancement, including CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats), Recombinant DNA technology, and Stem Cell Research. Then, it delves into the developments of medical biotechnology in developing countries and examines the opportunities and challenges faced during its progress. The medical biotechnology industry in most developing countries is relatively immature, so new opportunities appear as improving health outcomes and driving economic growth. Nevertheless, the development and adoption of medical biotechnology in developing countries are under different levels of financial burdens, so supports and collaborations on research and development from the healthcare leaders are essential. Finally, this research essay offers some suggestions to the cost reduction strategies of medical biotechnology in developing countries by promoting the hypothetical combination of value-based healthcare and modern monetary theory.

Keywords: Medical biotechnology; value-based healthcare; developing countries.

1. Introduction

Medical biotechnology is a field that merges biological science with medical research and technology while it has undergone remarkable advancements over the years and revolutionizing the landscape of healthcare. The history of medical biotechnology traces back to the early 1970s when scientists first successfully used recombinant DNA technology to splice genes from one organism into the DNA of another. This breakthrough allowed for the production of therapeutic proteins and vaccines on a large scale, marking the beginning of a new era in medical industry. Subsequent decades have witnessed further advancements, including the development of monoclonal antibodies, gene therapy, and the CRISPR-Cas9 gene-editing technology [1]. As the demand for innovative treatments grows, the medical biotechnology market continues to expand, with a focus on developing more effective and cost-efficient therapies.

However, along with these remarkable advancements, the development of medical biotechnology poses significant cost-related challenges in many developing countries. The high costs associated with research, clinical trials, and manufacturing often hinder accessibility to these cutting-edge treatments. The investment required for the development and commercialization of medical biotechnologies can be substantial, leading to higher product prices that may limit access for patients, particularly in low GDP per capita area. Despite these challenges, medical biotechnology presents tremendous opportunities for developing countries to improve healthcare outcomes and promote economic growth. If the medical system is under favorable regulations, embracing medical biotechnology can but not limited to enhancing medical infrastructure, generating substantial market revenues, improving employment opportunities, and stimulating innovations.

In light of these cost-related challenges and opportunities, healthcare leaders play a pivotal role in driving cost reduction efforts and ensuring the effective utilization of medical biotechnology. By adopting value-based healthcare approaches and exploring innovative financing strategies, healthcare leaders can navigate the complexities of biotechnology development and pave the way for a more equitable and sustainable healthcare future. In the following section, the study starts from exploring

specific examples of currently remarkable medical biotechnology, to the potential solutions for handling the costs in research and development.

2. Theoretical Analysis and Technical Application

Before a medical biotechnology product can be introduced to the market and used for patient care, it must go through evaluation and testing to ensure its safety, efficacy, and quality. The Food and Drug Administration (FDA) in the United States or the European Medicines Agency (EMA) in Europe are examples of regulatory agencies that assess the scientific data and supporting documentations submitted by the product's developers. The process of regulatory approval typically involves several stages, including preclinical studies, clinical trials, and the submission of a comprehensive application with all relevant data and findings. The regulatory agency thoroughly reviews the data to determine if the technology meets the required standards for safety and efficacy. If the technology successfully meets all the necessary criteria, then the regulatory agency issues a formal approval, allowing the product to be marketed and used by healthcare professionals to benefit patients. The upcoming sections present various examples of medical biotechnologies that are currently under development.

2.1. Recombinant DNA Technology

Recombinant DNA technology basically entails the alteration of genetic material from different sources to create novel genetic combinations. This technique has transformed the ability to engineer and modify genes, enabling the production of desired proteins, organisms, and traits. In the healthcare industry, recombinant DNA technology has enabled the production of pharmaceuticals, such as human insulin, human growth hormone, and vaccines. By inserting human genes into bacteria or yeast cells, scientists can produce large quantities of therapeutic proteins to treat various diseases, including anemia, Gaucher's disease, and cancer [2]. According to “Nova 1 advisor”, the global market value for recombinant DNA technology was valued to be USD 730.51 billion in 2022 and with an anticipated increase to USD 1202.46 billion by 2032, where the compound annual growth rate is approximately 5.1% during the forecast period 2022 to 2032.

2.2. CRISPR Technology

The more recent advancement of recombinant DNA technology, known as CRISPR technology, allows for the precise targeting and elimination of genes within human cells. The CRISPR technology is based on the adaptive bacterial immune system, where segments of the viral DNA are integrated into the bacterium’s genome within the CRISPR sequence. When the virus attacks again, the RNA copy of the viral DNA directs the Cas9 enzyme to locate and cleave the viral DNA at a specific sequence, and thus eliminate the virus effectively [3]. The use of CRISPR technology in various industries, including agriculture, healthcare, and biotechnology, has the potential to generate substantial profits. Pharmaceutical companies and biotech firms involved in CRISPR-based therapies are projected to gain significant profits from the commercialization of such treatments in the near future [4].

2.3. Stem Cell Research

Stem cells are known for their exceptional capacity to self-renew and differentiate into a variety of specialized cell types. Adult stem cells, which are extracted from the somatic tissues of fetuses or adults, and embryonic stem cells (ESCs), which are derived from the inner cell mass (ICM) of blastocyst embryos, are the two primary categories of stem cells [5]. Researchers are currently utilizing the ability of stem cells to develop regenerative medicine (RM), which aims to replace, engineer, or renew human cells, tissues, or organs. While there are still ethical concerns regarding stem cells research, regenerative medicine is a promising field that offers hope for patients with conditions like spinal cord injuries, heart diseases, and Parkinson's disease [6]. Grand View Research

estimates that the worldwide market for regenerative medicine was worth USD 42.87 billion in 2022 and is projected to grow at a compound annual growth rate of 15.7% from 2023 to 2030.

Through the above examples, it is evident that biotechnological innovations have the potential to revolutionize healthcare and improve the health outcomes of patients. The market sizes and revenues of the above medical biotechnological products are projected to be continue growing in the following decade, and thus attracting more and more attentions from the whole world. As medical biotechnology continues to advance, it holds the promise of shaping a healthier and more prosperous future for humanity. However, government supports on research and development and efficient healthcare policies are essential to ensure the equitable and sustainable application of these groundbreaking technologies. Although the current healthcare systems often encounter a range of challenges, the emerging medical biotechnologies offer the hopes of providing adequate and equitable cares to the populations in the future.

3. Medical Biotechnology in Developing Countries

The adoption and advancement of medical biotechnology can have a transformative impact on the healthcare system, in the way of both improving health outcomes and driving economic growth. On the one hand, by addressing prevalent public health challenges, such as infectious diseases and malnutrition, medical biotechnology innovate new treatments that can lessen the strain on healthcare systems and boost productivity. One notable example is the AstraZeneca covid vaccine created by Sarah Gilbert’s team from University of Oxford to against the Covid-19 pandemic. Gilbert's team initiated the process of vaccine development once the genome sequence of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was made available in January 2020. By employing the recombinant DNA techniques, they develop a SARS-CoV-2 antigen and incorporate it into a primate adenovirus vector [7]. Soon after, the Oxford AstraZeneca COVID vaccine succeed and was one of the earliest vaccine available for administration in the UK and globally amid the COVID pandemic. Undoubtedly, high efficacy of the vaccine development improves the overall human health outcomes by preserving millions of lives. On the other hand, medical biotechnology brings new economic opportunities by opening up avenues for personalized medicine, which is capable of satisfying the specific needs of diverse populations. Personalized medicine makes use of a patient's genetic information to inform disease prevention, diagnosis, and treatment, aiming to optimize medication and therapy choices. By tailoring treatments to individual patients, healthcare systems can achieve more efficient resource utilization, reduced hospital stays, and lower treatment costs, ultimately leading to cost savings and improved productivity [8]. Although personalized medicine is still under an early stage of development, its global market revenues exceed more than 500 billion US dollars in 2022. Given the rapidly expanding market size and its economic potential, personalized medicine deserves more attentions on its future directions.

Medical biotechnology in developing countries possess significant potential since the industry is not yet matured, where those unexplored territories might be able to generate substantial revenues and contribute to employment opportunities. However, the development and adoption of medical biotechnology in many developing countries, especially low-income countries, present unique economic challenges. In most African nations, insufficient government budgets inhibit the establishment of advanced laboratories, acquisition of cutting-edge technology, and recruitment of skilled researchers. For example, Uganda, an agrarian country located in East Africa, has been involved in development of agricultural and medical biotechnologies, specifically in combating with diseases like malaria and HIV/AIDS. The majority of the biotechnology funding in Uganda is from abroad through research and draw from competitive grants in the international community. To ensure sustainable funding for research and technology development, the government of Uganda should establish a reliable funding mechanism that offers predictable, transparent, and merit-based grants for research and innovation annually [9].

Additionally, the complexities of developing medical biotechnology can create barriers for businesses and investors seeking opportunities to enter these markets. In order to fully harness the economic possibilities offered by medical biotechnology, developing countries should invest in building a favorable environment for research and development. A strategy often adopted is the formation of public-private partnerships (PPPs). These collaborations between governmental bodies, academic institutions, and industry players can expedite research and development initiatives, stimulate innovation, and guarantee that biotechnological advancements result in concrete economic gains [10]. By providing financial incentives, tax breaks, and regulatory support, governments can encourage private sector investments in medical biotechnology, leading to job creation, economic growth, and improved access to healthcare technologies. For instance, the Medicines for Malaria Venture (MMV), a successful PPPs, has significantly contributed to the development of new antimalarial treatments for malaria-endemic regions, including Nigeria, the Democratic Republic of the Congo, and the Niger. MMV collaborates with pharmaceutical companies to accelerate the development of new antimalarial drugs and to ensure that the drugs are affordable and accessible to the populations [11]. These partnerships allow the sharing of knowledge, technology, and resources, which speeds up the drug discovery process and ensures that innovative treatments reach the market faster and are provided at reasonable prices. Another example is the Global Alliance for Vaccines and Immunization (GAVI), which has effectively increased access to vaccines in developing countries, thereby improving public health outcomes. Normally, GAVI negotiates with vaccine manufacturers to secure affordable and high-quality vaccines for partner countries. By leveraging the collective purchasing power of its partner governments, GAVI can negotiate favorable terms with vaccine suppliers [10]. This helps lower the cost of vaccines and makes them more accessible to countries with limited financial resources.

Furthermore, the economic perspective also demands attention to the ethical considerations associated with medical biotechnology. Besides, the limited availability of financial resources and healthcare infrastructure in developing countries may lead to disparities in access to medical biotechnologies among different socioeconomic groups. For instance, poorer elderly individuals in China and India report lower status of health compared to the elderly individuals in richest and middle-income groups. A similar pattern is observed in Cambodia, where the poorest older adults exhibit more adverse health conditions, and even minor improvements in income are correlated to better health outcomes [12]. In addition, developing countries often have a higher pressure on infectious diseases and health challenges affecting marginalized communities, including women, children, and refugees. Ethical guidelines must consider the inclusion of these vulnerable groups in medical biotechnology initiatives while ensuring that their rights and well-being are safeguarded. In other words, the decision-makers should prioritize projects that address pressing healthcare needs and have the potential to benefit a larger population. Ensuring equitable access to innovative therapies and technologies is crucial to avoid worsen the existing healthcare disparities in developing countries [12]. Policymakers and healthcare leaders must keep a balance between promoting economic growth and guarding the welfare of vulnerable populations to foster an inclusive and sustainable biotechnology ecosystem.

4. Potential Solutions of Handling Costs

As discussed in the previous sections, one of the primary challenges that hinder the development of medical biotechnology in many developing countries is the high financial burden. In order to solve the funding issues, the government might need to consider an alternative healthcare delivery model, the value-based healthcare. Value-based healthcare involves a shift from the traditional fee-for-service model to one that emphasizes patient outcomes and value for money [13]. By focusing on delivering better health outcomes at a lower cost, value-based healthcare encourages healthcare providers and policymakers to carefully assess the benefits and costs of medical biotechnology projects. This approach can lead to more rational decision-making in prioritizing investments in

technologies that offer the most significant impact on patient health and well-being. Value-based healthcare also promotes efficiency in healthcare delivery by reducing waste and unnecessary procedures. Developing countries can use this approach to optimize the utilization of medical biotechnology, ensuring that resources are directed towards treatments that provide the greatest value to patients and the healthcare system.

Besides, value-based healthcare itself is not enough to reduce the financial burden since the government deficits still exist as a problem in the orthodox monetary theory. The modern monetary theory, in contrast to the orthodox view, challenges conventional beliefs by suggesting that government deficits might not have the negative impact traditionally assumed, as governments possess the authority to generate the money in response to the deficit. Consequently, governments are unable to default on debt dominated in their own currency and thus allows spending in context where values are prioritized. This strategy will become increasingly important in administering medical healthcare all around the world, not only in developing countries [14].

Therefore, the combination of value-based healthcare and modern monetary theory offers to be an option for developing countries to address the cost problems associated with developing medical biotechnology. In conjunction with value-based healthcare, modern monetary theory challenges the traditional belief that governments are constrained by budget deficits and debt. According to this theory, governments with sovereign currencies have the ability to issue their currency and, therefore, have more flexibility in funding public institutes, including those in healthcare [15]. By adopting modern monetary theory, developing countries can mobilize funds to support medical biotechnology initiatives without relying solely on external funding or budget cuts in other critical sectors. This can lead to increased investment in research and development, and the establishment of supportive healthcare infrastructures for the successful implementation of medical biotechnologies. Moreover, modern monetary theory can help overcome financial barriers and foster innovation in medical biotechnology. It provides the framework for governments to fund long-term projects, such as biotechnological research, without excessive concerns about short-term budget deficits [14]. Thus, the combination of value-based healthcare and modern monetary theory can offer a comprehensive approach to address the high costs of developing medical biotechnology in developing countries. Value-based healthcare promotes efficiency and cost-effectiveness in healthcare investments, while modern monetary theory provides the financial flexibility needed to support critical medical biotechnology initiatives. Together, these approaches can help healthcare leaders of developing countries make informed decisions in allocating resources and investing in medical biotechnology to improve healthcare outcomes for their populations.

5. Conclusion

Medical biotechnology has emerged as a transformative force in the healthcare industry, offering innovative solutions for disease treatment and prevention. Three medical biotechnologies are introduced as examples of currently dominated cutting-edge technologies in the global market. This research essay highlights the economic perspective of medical biotechnology, addressing its developments in developing countries and cost implications. Most developing countries are in lack of professional laboratories, cutting-edge technology, and skilled researchers because of insufficient government budgets and high barriers of entry. Public-private partnerships (PPP), collaborations between governments, academic institutions, and industry players, is one strategy that has been often used to build a favorable environment for research and development in health sector. Additionally, policymakers and healthcare providers can play a pivotal role in achieving cost-effective and impactful biotech development. The combination of value-based healthcare and modern monetary theory encourage the healthcare leaders to focus on the health outcomes of patients instead of unnecessary concerns to budget deficits. There are still unpredicted challenges in the development of healthcare system in developing countries, but embracing the potential of medical biotechnology will pave the way for a healthier and more prosperous future.

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