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ORIGINAL ARTICLE

Enhancing Global Biomedical Research: Educational Strategies for Bridging the Gap between HICs and LMICs

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Abstract

There is a pressing need to address the noticeable disparity in biomedical research output between High-Income Countries (HICs) and Low-Middle Income Countries (LMICs). This imbalance raises urgent concerns about equity and the impact on global health. Despite being home to most of the global population, LMICs face numerous challenges that hinder their ability to contribute significantly to research. This review explores the factors contributing to the disparities and proposes potential solutions to address this global imbalance. A comprehensive strategy is needed to tackle the differences in biomedical research productivity between high-income and low-middle-income nations. Enhancing global partnerships, ensuring fair allocation of resources, and prioritizing the development of research capabilities are crucial measures in nurturing a more diverse and influential worldwide biomedical research landscape. Closing this divide is essential for advancing scientific inclusivity and tackling the health issues economically disadvantaged countries face.

Keywords: Research; Developing Countries; Publications; Biomedical Science

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Summary

What was already known?

- There is a significant gap in the amount of biomedical research produced by HICs compared to LMICs. LMICs need more resources, infrastructure, and trained personnel, hindering their ability to conduct research.

Why this study was needed?

- A recent review needs to be conducted to summarize the factors causing this imbalance, and this study aims to identify specific solutions to bridge the gap.

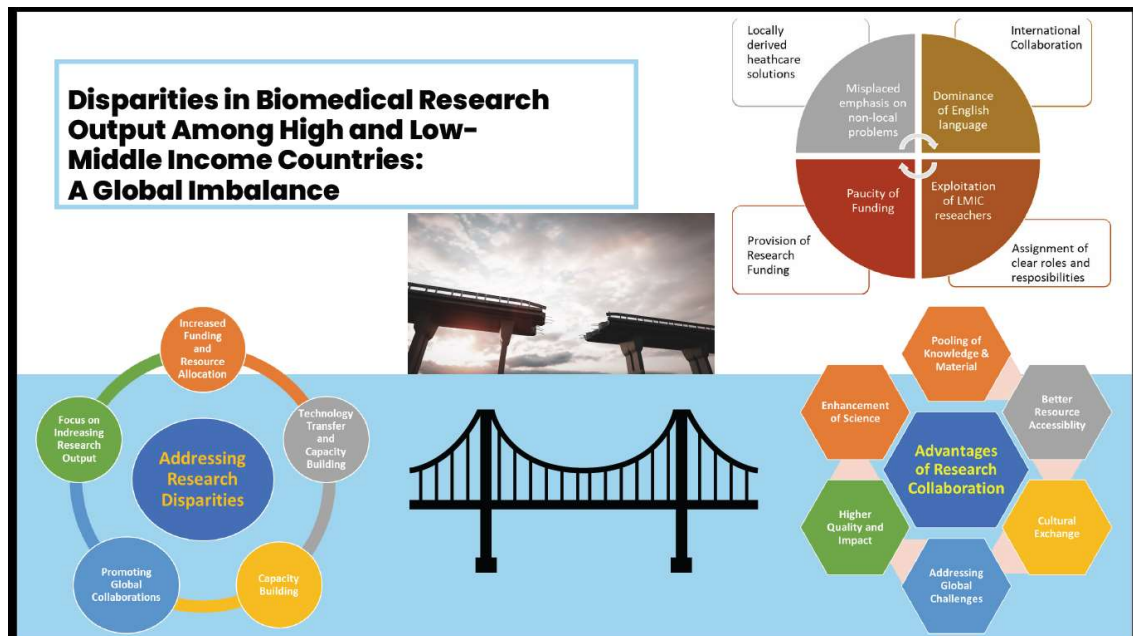
What this study adds?

- This study offers a fresh perspective by providing a comprehensive analysis of the factors creating the disparity in biomedical research output. It proposes recommendations to address the identified challenges, offering a new approach to bridging the gap between HICs and LMICs.

How this study might affect research, practice, or policy?

- This study can encourage collaboration between HIC and LMIC institutions and urge funding bodies to provide a fair allocation of resources for research, potentially directing more funding towards LMICs.
- The study's emphasis on building research capacity in LMICs can encourage policy decisions to invest in education and training programs for researchers in those countries.

Graphical Abstract



Introduction

Research is pivotal in advancing healthcare and enhancing our understanding and treatment of various diseases. It is also an essential indicator of a country's scientific and academic capabilities. The World Bank categorizes economies into these groups based on Gross National Income (GNI). As of July 2021, the World Bank's classifications were: Low income: Less than \$1,045 per capita GNI; Lower-middle income: \$1,046–\$4,095 per capita GNI; Upper-middle income: \$4,096–\$12,695 per capita GNI; and High income: More than \$12,695 per capita GNI [1]. LMIC and HIC are abbreviations for low- and middle-income countries and high-income countries, respectively. A noticeable disparity in research output between HICs and LMICs raises concerns about equity and the impact on global health [2]. Despite being home to most of the global population, LMICs face numerous challenges that hinder their ability to contribute significantly to research. It has led to a significant gap, known as the "10/90 gap," where only a tiny portion of global health research funding is allocated to addressing the health problems affecting most of the world's population, particularly low-income people [3]. Despite various stakeholders' efforts, this gap persists.

This review aims to explore the factors contributing to the disparities in biomedical research output between HICs and LMICs and propose potential solutions to address this global imbalance. These disparities need to be addressed as they significantly impact global health.

Challenges

Healthcare systems in HICs often possess advanced infrastructure, well-trained healthcare professionals, and comprehensive access to medical technologies. However, these advantages come with their own set of challenges. The high costs associated with these systems can strain healthcare budgets and potentially lead to over-reliance on technology. Additionally, the complex administrative structures can create inefficiencies and hinder care delivery.

On the other hand, LMICs face their unique challenges in healthcare. Access to healthcare facilities, a need for more trained personnel, and a scarcity of essential medical resources can impede the delivery of quality care. Furthermore, these countries often need help with budgetary constraints, infectious disease burdens, and inadequate preventive care measures.

Addressing these disparities requires tailored strategies that consider each country's specific circumstances. It is crucial to ensure equitable and effective healthcare delivery. This approach can be achieved through collaborative efforts, international partnerships, and targeted investments. By working together, countries can bridge the gaps in healthcare and promote more equitable contributions to global research efforts.

Factors Contributing to Disparities

The disparities in research output between LMICs and HICs are influenced by various factors, as outlined in Table 1.

Table 1. Contributing Factors for disparities in research output of High-Income and Low-Middle Income countries

Contributing Factors	High-Income Countries	Low-Middle Income Countries
Funding for Research & Development	Substantial resources	Limited resources
Infrastructure & Technology	Well-established institutions and facilities	Limited facilities
Education Systems	Existing robust education systems	Inadequate education systems
Collaborative Networks	Established extensive networks	Poor collaborating networks
Research Productivity	Dominate publications in high-impact journals	Limited research output
Research Priorities and Global Health	Different disease profiles compared with Low and Low-middle-income countries	Different disease profiles compared with High-Income countries

Funding Limitations

The unequal distribution of funds between HICs and LMICs significantly influences the research output gap. HICs allocate substantial financial resources to Research and Development (R&D), allowing them to engage in large-scale, innovative research endeavours. Conversely, LMICs often face financial constraints that impede their ability to conduct extensive research. Developed nations have more financial resources for biomedical research, enabling them to invest in cutting-edge technologies, state-of-the-art infrastructure, and comprehensive training programs. In contrast, many developing countries need more funding, which limits their competitiveness in the global research arena.

Infrastructure and Technological Constraints

The absence of sophisticated research infrastructure and state-of-the-art technology in LMICs contributes to the existing disparities in research output. High-income countries boast well-established research institutions with cutting-edge facilities, enabling their scientists and researchers to conduct groundbreaking work. Conversely, LMICs need help in obtaining and sustaining such infrastructure.

Collaborative Networks

Developed countries have the advantage of being part of extensive national and international collaborative networks, facilitating the exchange of knowledge and initiating joint research

projects. On the other hand, UMICs LMICs need help establishing and sustaining such global partnerships, which hinders their access to a wide range of perspectives and expertise.

Publications and Citation Discrepancies

The evaluation of research productivity is commonly based on the number of publications and citations. Developed nations are predominant in the scientific literature, with their academic institutions and researchers consistently contributing to high-impact journals. Conversely, scholars from developing countries often need help gaining recognition, affecting their citation rates and overall influence.

Research Priorities and Global Health

Global health inequalities persist as research priorities frequently mirror the prevalent diseases in more affluent regions, overlooking illnesses that disproportionately affect individuals in resource-constrained settings.

Challenges and Solutions in Research of Low-middle-income countries

Challenges

LMICs face numerous challenges in improving healthcare and research. In addition to limited access to high-quality care, these countries contend with competing health priorities, fragile health systems, and conflicts. Another significant obstacle is the need for more evidence generation and research within LMICs. However, one crucial aspect of addressing these challenges is recognizing and taking ownership of the problem of insufficient local evidence by all stakeholders involved. This recognition makes them feel more responsible and motivated to contribute to the solution. Collaboration between HICs-

LMICs and LMICs-LMICs can be instrumental in overcoming these challenges. Such partnerships can increase resources, capacity building, and long-term productivity [4].

HICs possess robust economies, advanced infrastructure, and high living standards. Their citizens generally have access to quality healthcare, education, and a comfortable standard of living. These nations also contribute significantly to Research and Development (R&D) efforts. In contrast, LMICs face economic challenges that hinder their rapid development. They often struggle with issues such as poverty, limited access to education, and inadequate healthcare infrastructure. The relationship between a country's Gross Domestic Product (GDP) and biomedical research output is complex. While higher GDP generally leads to increased funding for R&D, the connection is not linear. Other factors, including government policies, education, and healthcare infrastructure, also play crucial roles in research productivity on a global scale. A study on Asian countries found that those allocating more funds to R&D tend to have better research outcomes, including more publications, citations, and h-index in various science and social science subjects [5].

Publishing research in prestigious journals presents another hurdle, as these journals often have high rejection rates. LMIC researchers must also improve their ability to conduct randomized controlled trials (RCTs). They are often compared unfavourably to such studies, necessitating a defence of their study choices and the robustness of their evidence. Another challenge arises from the expectation that every surgical innovation must align with the five stages of the IDEAL framework,

which may only sometimes be feasible for affordable solutions. Despite successfully publishing affordable ideas, a significant gap exists between their publication and their actual dissemination and adoption in LMICs. It compels researchers to develop a roadmap that effectively bridges this gap [6].

Academic publishing is a crucial part of a clinician's career. Writing a scientific article can be challenging, but it strengthens research, writing, and communication skills. It also helps clinicians critically evaluate literature and apply new knowledge in patient care [7]. One of the main limiting factors found in publishing has been limited skills in English writing and editing. Apart from other reasons for publication bias, poor use of English is also cited as a reason for the rejection of submitted articles. This does not appear surprising since 90% of international journals are published in the English language. Analysis of 70 orthopaedic journals indexed in Medline assessing the country of origin of publications showed 50% of journals were published in the US, 40% in the UK and only 10% from the East and Latin America. This over-representation of UK-English-based and US-English-based publications in the literature may be one of the reasons for language bias and subsequent rejection of a manuscript from non-English practising authors [8].

Solutions

LMIC researchers need help conducting research within their resource-limited environments. One of the initial difficulties they encounter is the lack of external assistance, which forces them to find solutions to pressing issues independently. To navigate these challenges, researchers can apply the principles of Global Surgery, such as leveraging Occam's razor and adopting a "Modify-Simplify-Apply" approach. Additionally, they must disseminate their research through scientific papers for peer review and acceptance within the professional community. There needs to be a template or guideline for documenting low-cost and frugal innovations, which poses another obstacle, prompting researchers to create their own [6].

Bridging the Gap

Bridging the gap in research output between LMICs and high-income countries, HICs are paramount in creating a more balanced and fairer global scientific environment. It can be achieved by addressing financial limitations, enhancing infrastructure, advocating for education, and fostering international partnerships. By implementing the following strategies (Figure 1), the international community can make significant progress in narrowing the disparities and fully utilizing the valuable research contributions from various regions.

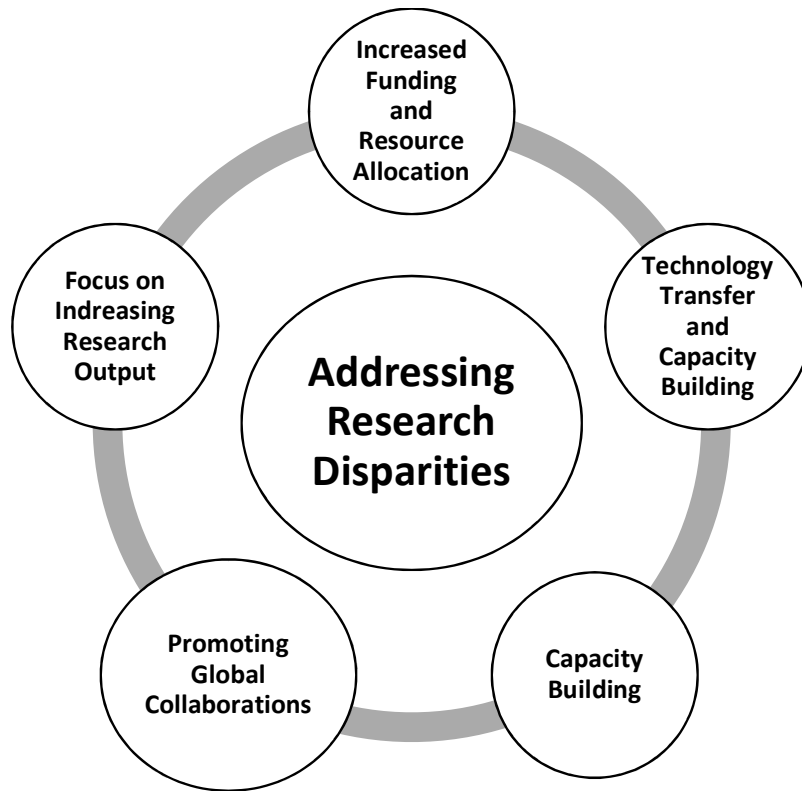


Figure 1: Strategies to address the disparities in the research output between High and Low-Middle Income Countries

Enhanced Research Resource Allocation and Funding

To address the research output gap, international organizations, governments, and philanthropic foundations must enhance their support by allocating more funding and resources to LMICs. It can be achieved through various means, such as providing financial assistance to local research initiatives, investing in research infrastructure development, and offering scholarships to promote education and skill development among researchers in these countries.

Providing Financial Assistance to Local Research Initiatives involves direct funding and investment in infrastructure. Direct funding can take the form of grants allocated to specific research projects led by local institutions in LMICs, such as the

Gates Foundation supporting malaria research of US\$140 million as a commitment over four years for African institutions [9]. Additionally, fellowships can provide financial support to individual researchers in LMICs, exemplified by the Wellcome Trust's offering to scientists in sub-Saharan Africa of \$40 million over five years [10]. Collaborative research funding supports joint projects between LMICs and HICs, as demonstrated by the NIH Fogarty International Center's partnerships between US and African researchers on HIV/AIDS [11].

Technology Transfer

Efforts to bridge the technological gap between HICs and LMICs should prioritize technology transfer initiatives. These initiatives should focus on

facilitating the exchange of knowledge and expertise between the two groups. By promoting the transfer of technology, LMICs can benefit from the advancements made by HICs, enabling them to overcome technological barriers and enhance their research capabilities. Research infrastructure development involves providing funds for laboratory equipment and facilities, like the World Bank's support for a new research center at the University of Nairobi [12].

Capacity Building

Capacity-building programs hold great potential in empowering researchers in low-resource settings. These programs aim to equip researchers with the necessary skills and tools to conduct high-quality research. By providing training and support, capacity-building initiatives can help researchers in LMICs overcome challenges related to limited resources and enhance their research capacity. Furthermore, investing in robust data collection and analysis infrastructure is crucial, as exemplified by the Global Fund's support for data management systems for HIV surveillance in LMICs [13].

Promoting Global Collaborations

Promoting inclusive collaborations is essential in integrating LMICs into the global research community. Initiatives that foster partnerships, mentorship programs, and joint research projects can contribute to a more equitable distribution of knowledge and resources. While developed nations have well-established research ecosystems that encourage collaboration and provide ample opportunities for scientists, LMICs often face barriers such as limited access to international collaborations, cutting-edge facilities, and a supportive research

environment. These barriers can be overcome by promoting global collaborations, allowing LMICs to actively contribute to and benefit from the global research community.

Establishing connections between HICs and LMICs in biomedical research has yielded significant results. For instance, the African Center of Excellence for Malaria Research in Kenya [10] has cultivated strong partnerships with leading research institutions in Europe and North America, leading to collaborative research projects and high-impact publications in top-tier biomedical journals. Similarly, the India-US Science and Technology Cooperation has fostered collaborations between Indian and American researchers in biotechnology, nanotechnology, and climate change, resulting in high-impact publications [14]. Brazil's participation in the Human Genome Project has strengthened its domestic biomedical research capabilities and led to fruitful collaborations with researchers from developed countries, as evidenced by joint publications in prestigious scientific journals [15].

Growth of research output

The data provided in this study indicates that developing countries still have a significant distance to cover in order to contribute a more balanced share to the global scientific community. However, there are reasons for optimism. Despite limited financial resources, many developing nations exhibit remarkably high levels of scientific productivity. Increased investment in scientific research by developing countries could yield positive results, mainly if these publications target high-impact journals [16]. While progress is still being made, connections are

gradually being established between HICs and LMICs in biomedical research.

With significant investments in agriculture, aviation, and biofuels, Brazil has seen a surge in research output. Brazilian researchers increasingly publish in top-tier journals such as Science, Nature, and The Lancet. India's focus on information technology and pharmaceuticals has fuelled a rapid expansion of scientific publications [17]. Indian researchers have made substantial contributions to nanotechnology, biotechnology, and space science, with numerous studies appearing in high-impact journals [18]. South Africa's investments in medical research, particularly HIV/AIDS and tuberculosis, have led to many South African scientists publishing in renowned medical journals [19].

Global Health and Surgery

Interest in global health is on the rise. Hodson et al. have identified key challenges in global health, including the lack of direct funding available for scientists in LMICs, the focus on issues selected by HICs rather than local solutions to local problems, the dominance of the English language in scientific literature, and the exploitation of team members from LMICs. In order to address these challenges, several strategies are proposed, such as seeking solutions relevant to local contexts, fostering collaborations between institutions in HICs and LMICs, providing funding for team members from both types of countries, and clearly defining roles and responsibilities for all team members [20].

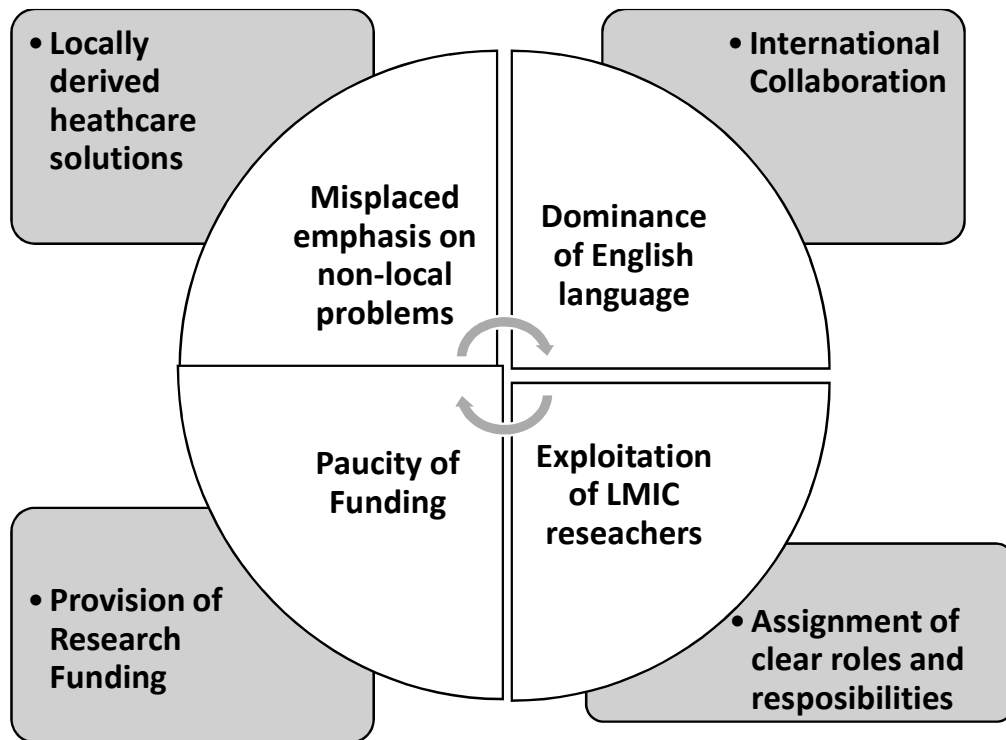


Figure 2. Problems and solutions to the global health problems (Adapted from Hodson et al. [20])

The lack of proper surgical care goes far beyond the immediate suffering it causes. It creates a ripple effect with severe economic and social consequences. Untreated surgical conditions can lead to lost productivity, financial hardship, and a strain on healthcare systems. Socially, these conditions disrupt education, employment, and family life, widening the gap between social classes. Public health is also impacted, as preventable surgical diseases can contribute to the spread of infections and other health problems. Thankfully, global surgery initiatives are working to change this. By highlighting the critical role of surgery and advocating for increased investment, they aim to reduce preventable deaths and disabilities, strengthen healthcare systems with better infrastructure and trained personnel, and ultimately promote equitable access to essential surgical care for everyone, regardless of background. In essence, ensuring access to surgery is fundamental to achieving universal health coverage, reducing global health disparities, and improving the overall well-being of populations worldwide.

Global surgery initiatives are dedicated to enhancing surgical care and accessibility worldwide. These efforts address disparities in surgical outcomes, infrastructure, and workforce across different regions. The main objectives include improving surgical capacity, ensuring safety, and equitably distributing resources to meet global populations'

diverse surgical needs. Collaboration among healthcare professionals, organizations, and governments is essential for advancing global surgery and achieving sustainable enhancements in surgical care. Despite the progress, the journey towards achieving equal access to surgical care is ongoing. The global community must work together to ensure that everyone has access to surgical equity [21]. Research disparities exist between the global north and south due to unequal access to resources, funding, and educational opportunities. Historical and systemic factors, including colonial legacies, also contribute to these disparities. Addressing these imbalances should focus on promoting inclusivity, supporting research infrastructure, and fostering global collaboration. Collaboration between the global north and south is essential. A study tracking data from 82 natural science journals indicated a significant imbalance in north-south authorship, with a ratio heavily favouring the global north by almost 3 to 1. It was emphasized that there is still a significant gap in global north-south research equity [22].

Importance of Research Collaboration

Research collaboration is considered crucial in biomedical research [23]. The advantages of international research collaborations are multifaceted (Figure 3), as these help advance science and address complex global challenges by leveraging diverse expertise.

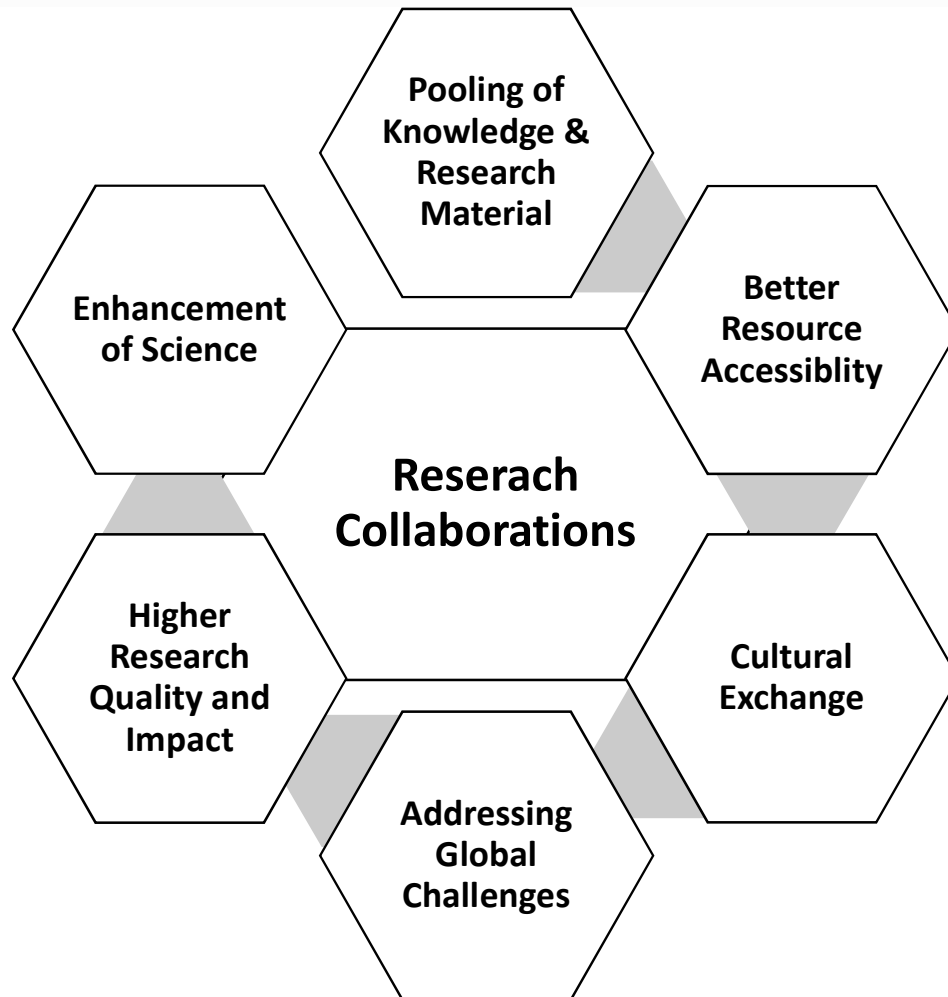


Figure 3. Perceived Advantages of Research Collaboration

It enhances the pooling of knowledge and resources, whereby researchers from different countries can bring unique perspectives, skills, and experiences on a common platform. Collaborative research allows for the integration of diverse ideas, methodologies, and data, fostering a richer understanding of complex phenomena. This 'collective intelligence' often leads to more comprehensive and innovative research outcomes. It increases the number of co-authors and the citation index and overall increases the productivity of the researchers. A study of six leading journals

found that the authors who published collaborative studies produced superior manuscripts in higher impact factors journals [24].

Furthermore, international collaboration can facilitate access to resources like funding, research facilities, and specialized equipment [25-27]. This collaborative effort can accelerate research progress and may also be cost-effective. In addition, such global collaboration helps promote cultural exchange and mutual understanding amongst researchers, contributes to knowledge dissemination,

and is instrumental in addressing global challenges.

However, to ensure ethical research collaborations, it is crucial to address issues such as fair attribution, intellectual property, conflict of interest, data sharing, power dynamics, cultural sensitivity, open science, and conflict resolution [28,29].

Conclusion

A comprehensive strategy is needed to tackle the differences in biomedical research productivity between high-income and low-middle-income nations. Enhancing global partnerships, ensuring fair allocation of resources, and prioritizing the development of research capabilities are crucial measures in nurturing a more diverse and influential worldwide biomedical research landscape. Closing this divide is essential for advancing scientific inclusivity and tackling the health issues economically disadvantaged countries face.

Statements and Declarations

Conflicts of interest

The authors declares that they do not have conflict of interest.

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Ethical Approval

Not required for such bibliometric study

Data availability

The raw data is available with the corresponding author.

Author's contribution

RV: Conceptualization, Data Analysis, Literature Search, Manuscript

writing, editing and final approval. DS: Conceptualization, Data Curation and Analysis, Literature Search, Manuscript writing, editing and final approval. AS/BP/MM/AV: Data Analysis, Literature Search, Manuscript writing, editing and final approval.

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