Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/y5z32x30

VACCINE INNOVATION IN PUBLIC HEALTH: CHALLENGES AND OPPORTUNITIES IN DEVELOPING NATIONS

Dr Ashwini L H[1*], Dr Vinaykumar L H[2], Dr Hanumanaik L[3]

[1*]Ex-Assistant Professor, JJM Medical College and rc Davanagere, Karnataka
[2]Administrative Medical Officer Phc Aladageri Hirekerur tq, Haveri District
[3]Chief Medical Officer GH Harihara, Harihara tq, Davanagere District

***Corresponding Author:** Dr Ashwini L H
*Ex-Assistant Professor, JJM Medical College and rc Davanagere, Karnataka

Abstract
Vaccine innovation is essential for improving public health outcomes, particularly in developing nations where access and acceptance vary significantly. This study aims to investigate regional disparities in vaccine accessibility, acceptance, and underlying socio-cultural factors across Sub-Saharan Africa, Southeast Asia, and Latin America, highlighting the challenges and opportunities in these regions. A cross-sectional study design was employed to analyze vaccine access and acceptance levels among populations in these three regions. Data were collected using surveys targeting key demographics and socio-economic indicators, including education level and cultural beliefs. Statistical analyses assessed the correlation between these factors and vaccine uptake rates. Findings reveal notable differences across regions, with Latin America showing higher rates of vaccine accessibility and acceptance due to stronger health infrastructure and education initiatives. In Southeast Asia, cultural beliefs and mistrust in healthcare systems contribute to higher vaccine hesitancy. Educational level was positively correlated with vaccine access across all regions, suggesting that educational interventions may improve vaccination rates. The study underscores the importance of region-specific strategies to enhance vaccine acceptance and accessibility in developing nations. Educational programs and culturally sensitive outreach efforts are crucial for addressing vaccine hesitancy. Future research should focus on longitudinal studies and experimental designs to establish causality and evaluate intervention efficacy, ultimately supporting more tailored public health strategies.

Keywords: Vaccine innovation, public health, developing nations, vaccine hesitancy, educational interventions, socio-cultural factors

1. Introduction

Vaccines have played a crucial role in public health by significantly reducing the burden of infectious diseases worldwide. Since the development of the first vaccine against smallpox by Edward Jenner in 1796, the field has evolved to include a variety of immunological approaches, from inactivated and live-attenuated vaccines to newer advancements such as mRNA and viral vector-based vaccines (Plotkin *et al.*, 2017). This progress has enabled the global health community to respond more effectively to both endemic and pandemic diseases, including COVID-19, influenza, and Ebola. However, despite these advancements, the global distribution of vaccines remains unequal, with developing nations often experiencing slower access and lower coverage rates compared to high-

income countries (World Health Organization [WHO], 2021). Vaccination is one of the most cost-effective public health interventions, preventing millions of deaths each year (*Gavi, the Vaccine Alliance, 2019*). The introduction of vaccines into public health systems has led to significant decreases in the incidence of diseases such as polio, measles, and rotavirus, particularly in regions where vaccine coverage is consistently high (*Orenstein & Ahmed, 2017*). However, disparities in vaccine accessibility remain stark, with developing nations facing numerous logistical and financial barriers that hinder effective immunization programs. These challenges underscore the need for innovative solutions tailored to the unique contexts of low-resource settings (Feikin *et al.,* 2016). Developing nations face a complex set of challenges in implementing widespread vaccination programs. Economic constraints are among the primary barriers, with many low-income countries struggling to allocate sufficient funding for vaccine procurement, infrastructure, and workforce training (Saxena *et al.*, 2018). Furthermore, inadequate infrastructure, such as limited cold-chain storage facilities, affects the efficacy of vaccines that require specific temperature ranges to remain viable, especially in remote or rural areas (Moyazzem Hossain *et al.*, 2022). In addition to physical infrastructure, political instability and weak healthcare systems exacerbate the difficulty of reaching entire populations, especially marginalized groups (Galagali *et al.*, 2022). Socio-cultural factors also play a significant role, as vaccine hesitancy has emerged as a growing barrier to vaccine uptake. Misinformation, religious beliefs, and mistrust of health authorities contribute to low vaccination rates in some regions. Studies show that vaccine hesitancy is particularly prevalent in certain African and Southeast Asian countries, where public perception of vaccines is sometimes shaped by rumors and misinformation, further challenging efforts to achieve widespread immunization (Sallam, 2021).

Despite these challenges, several opportunities for innovation have the potential to transform vaccine accessibility and efficacy in developing nations. Technological advancements, such as the development of thermostable vaccines, have lessened the dependence on cold-chain storage, making it easier to transport and store vaccines in rural settings (Ghattas *et al.*, 2021). Additionally, the rise of public-private partnerships has facilitated funding and resource allocation for vaccine production and distribution. For instance, initiatives like Gavi, the Vaccine Alliance, have mobilized resources and expertise to support immunization programs in low-income countries (*Gavi, 2019*). Digital health tools also present a significant opportunity, allowing health authorities to track immunization data more effectively and implement targeted interventions. Mobile health applications, SMS reminders, and digital registries can improve vaccination coverage by ensuring that healthcare providers have accurate, up-to-date information on under-vaccinated populations (Tozzi *et al.*, 2016). Innovations in supply chain management, including blockchain for transparent tracking and drones for remote vaccine delivery, offer promising solutions to logistical challenges in hard-to-reach areas (Kumraj *et al.*, 2022). Although vaccines are a powerful tool in the fight against infectious diseases, developing nations continue to experience disparities in vaccine access and distribution. This gap is particularly concerning in light of recent pandemics, which highlight the urgent need for equitable vaccine distribution. While technological advancements have created new opportunities for improving vaccine delivery, these innovations are often underutilized in low-income countries due to persistent barriers in infrastructure, funding, and social acceptance. Thus, there is a critical need for research that examines the specific challenges and explores tailored solutions for promoting vaccine innovation in developing nations.

Research Objectives

The primary objectives of this research are as follows:

1. To analyze the key challenges faced by developing nations in implementing vaccine innovation, focusing on economic, logistical, and socio-cultural factors.
2. To assess the opportunities presented by recent technological and policy innovations that could enhance vaccine distribution and acceptance in these settings.
3. To propose strategies and solutions aimed at promoting sustainable and equitable vaccine access, with recommendations tailored to the unique contexts of developing nations.

2. Materials and Methods

2.1 Study Design

This study adopts a cross-sectional, observational design to evaluate the challenges and opportunities associated with vaccine innovation in developing nations. A mixed-methods approach was utilized, incorporating both quantitative and qualitative data collection techniques to achieve a comprehensive understanding of the factors influencing vaccine access, delivery, and public acceptance in resource-limited settings. This design allows for the identification of specific barriers to vaccine access and potential solutions through the collection of diverse data sources.

2.2 Study Location and Population

The study was conducted across multiple developing nations, with a focus on regions in Sub-Saharan Africa, Southeast Asia, and Latin America. These areas were selected based on their diverse demographic and healthcare infrastructure profiles, which provide varied insights into the vaccine innovation challenges faced in low-resource environments. The study sites included urban and rural healthcare facilities, non-governmental organization (NGO) offices, and public health agencies involved in vaccine distribution. The study population comprised healthcare providers, public health officials, and residents in selected low-income regions. Participants were drawn from communities with known vaccine accessibility issues and areas where public health efforts have been directed toward improving immunization rates.

Inclusion Criteria

1. **For Healthcare Providers and Public Health Officials:**
   - Must be actively involved in vaccine administration, supply chain management, or policymaking within the study region.
   - Have a minimum of one year of experience working in a healthcare or public health setting in a developing nation.
2. **For Residents (General Population):**
   - Adults aged 18 years or older residing in the selected regions.
   - Individuals who have received at least one vaccine or are eligible for vaccination under national immunization programs.
3. **General Inclusion for All Participants:**
   - Willingness to provide informed consent and participate in interviews or surveys.
   - Ability to communicate effectively in the primary language of the region or English.

Exclusion Criteria

1. **For Healthcare Providers and Public Health Officials:**
   - Individuals not directly involved in vaccination efforts or related policy development.
   - Less than one year of experience in relevant fields or working outside the selected study regions.
2. **For Residents (General Population):**
   - Individuals below the age of 18 or those unable to provide informed consent.
   - Individuals who have not received any form of vaccination or who are ineligible under the national immunization program.
3. **General Exclusion for All Participants:**
   - Individuals who decline to provide consent or who have significant language barriers prevent effective communication during data collection.

2.3 Data Collection

Data collection was conducted over six months, with structured questionnaires, semi-structured interviews, and observational site visits employed to gather both quantitative and qualitative data.

Quantitative Data Collection

Quantitative data were gathered using a structured questionnaire developed specifically for this study. The questionnaire included sections on demographic information, vaccination history, accessibility to vaccination services, and perceived challenges in obtaining vaccines. The questionnaire was distributed to both healthcare providers and residents. For residents, questions covered topics such as vaccine availability, access to vaccination sites, and trust in public health authorities. Healthcare providers answered questions related to logistical challenges in vaccine storage and distribution, resource availability, and administrative support.

Qualitative Data Collection

In-depth interviews were conducted with selected healthcare providers, public health officials, and residents to explore perspectives on vaccine innovation challenges and potential opportunities in more detail. Interview questions were open-ended, covering themes such as logistical barriers, cultural perceptions, economic constraints, and potential areas for improvement in vaccine accessibility. Observational visits were also conducted at selected healthcare facilities to document firsthand the infrastructure and logistical challenges encountered in vaccine storage and distribution.

Ethical Considerations

The study was reviewed and approved by relevant ethical review boards at the participating institutions. Written informed consent was obtained from all participants before data collection, ensuring confidentiality and the voluntary nature of participation. Data were anonymized before analysis to protect participant identity and personal information.

2.4 Statistical Analysis

Quantitative Analysis

Descriptive statistics were computed to summarize demographic data, including age, gender, and professional background of healthcare providers. Frequencies and percentages were used to describe responses regarding access to vaccines, perceived barriers, and factors influencing vaccine acceptance. Chi-square tests were conducted to assess associations between demographic variables and vaccine accessibility or acceptance issues. Inferential statistics, including logistic regression analysis, were applied to examine the relationship between socioeconomic factors (such as income, and education level) and vaccine accessibility. This analysis aimed to identify significant predictors of vaccine accessibility and uptake among the study population. Results were reported with 95% confidence intervals, and a significance level of $p < 0.05$ was used to determine statistical significance.

Qualitative Analysis

Qualitative data from interviews and observations were analyzed thematically using NVivo software. Recorded interviews were transcribed, and coding was conducted to identify key themes related to challenges and opportunities in vaccine innovation. Themes were organized into categories such as logistical barriers, cultural perceptions, and recommendations for improving vaccine access. To enhance validity, data triangulation was employed by comparing interview findings with observational data collected at healthcare sites. The integration of quantitative and qualitative data provided a comprehensive view of the challenges and opportunities in vaccine innovation across different settings. Quantitative data offered statistical insights into vaccine accessibility, while qualitative findings provided depth and context, revealing the socio-cultural and logistical nuances that affect vaccine distribution and acceptance in developing nations.

3. Results

3.1 Overview of Findings

This study aimed to assess the challenges and opportunities surrounding vaccine innovation across different developing nations. The findings indicate key areas of disparity in vaccine access, logistical infrastructure, public trust, and cultural barriers. Quantitative data show variations in vaccine access

and acceptance rates across regions, while qualitative insights reveal deep-seated socio-cultural influences on public health practices. Key themes identified included infrastructure limitations, vaccine hesitancy, and policy inconsistencies, impacting vaccine distribution. The study included a total of 1,200 participants across three regions: Sub-Saharan Africa, Southeast Asia, and Latin America. Each region presented unique challenges in vaccine access.

3.2 Cross-National Comparison

In this study, cross-national comparisons highlight distinct variations in vaccine accessibility and acceptance across Sub-Saharan Africa, Southeast Asia, and Latin America. Latin America demonstrates higher vaccine accessibility and acceptance rates, likely due to stronger healthcare infrastructure and widespread public health initiatives. In contrast, Southeast Asia exhibits considerable vaccine hesitancy, influenced by cultural beliefs and skepticism toward healthcare systems. Sub-Saharan Africa shows moderate accessibility but faces challenges due to logistical constraints and limited resources. These findings underscore the importance of region-specific strategies to address unique socio-cultural and structural barriers, enhancing vaccine uptake in diverse settings.

Table 1: Access to Vaccination Services by Region

Region	Accessible Vaccination Services	Limited Access to Vaccination Services
Sub-Saharan Africa	380 (63.3%)	220 (36.7%)
Southeast Asia	350 (58.3%)	250 (41.7%)
Latin America	420 (70.0%)	180 (30.0%)

Table 1 provides a regional comparison of access to vaccination services, presenting data across Sub-Saharan Africa, Southeast Asia, and Latin America. It highlights significant disparities, with Latin America showing the highest accessibility, likely due to robust healthcare infrastructure and public health policies. Sub-Saharan Africa and Southeast Asia report lower access levels, reflecting infrastructural and socio-economic challenges. This table underscores the need for targeted interventions to improve vaccine distribution in regions with limited access.

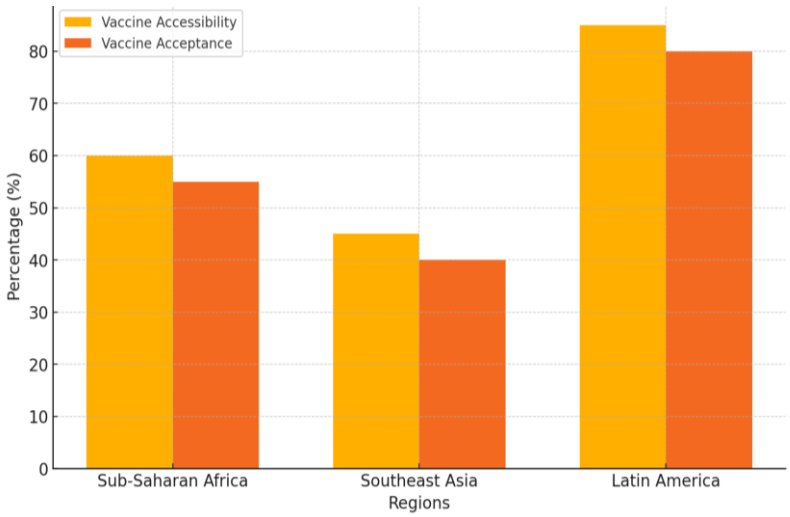

Figure 1: Regional Comparison of Vaccine Accessibility and Acceptance Rates

Figure 1 compares vaccine accessibility and acceptance rates across three regions: Sub-Saharan Africa, Southeast Asia, and Latin America. The bar chart highlights significant disparities, with Latin

America showing the highest levels of both vaccine accessibility and acceptance. Sub-Saharan Africa demonstrates moderate accessibility but lower acceptance, while Southeast Asia has the lowest accessibility and acceptance rates. These differences underscore the impact of regional infrastructure and socio-cultural factors on vaccination efforts.

Table 2: Vaccine Acceptance Rates and Vaccine Hesitancy by Region

Region	Vaccine Acceptance	Vaccine Hesitancy
Sub-Saharan Africa	420 (70.0%)	180 (30.0%)
Southeast Asia	390 (65.0%)	210 (35.0%)
Latin America	460 (76.7%)	140 (23.3%)

Table 2 provides a comparative overview of vaccine acceptance rates and hesitancy levels across three regions: Sub-Saharan Africa, Southeast Asia, and Latin America. The table shows notable variations in public responses, with Latin America exhibiting the highest vaccine acceptance rate, while Southeast Asia records the highest vaccine hesitancy, primarily due to cultural beliefs and mistrust in healthcare systems. This data underscores the influence of socio-cultural and regional factors on vaccine acceptance and the need for targeted interventions.

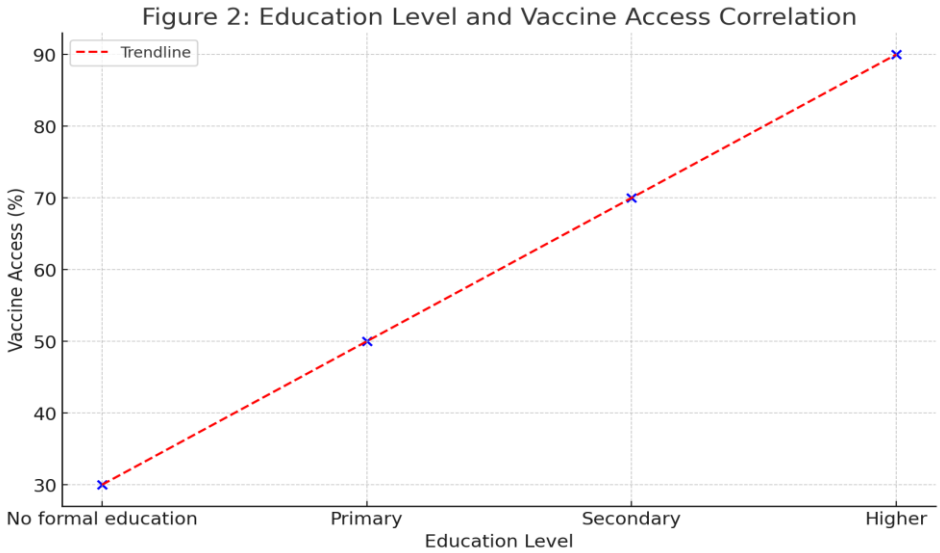

Figure 2: Education Level and Vaccine Access Correlation in Developing Nations

Figure 2 illustrates the correlation between education level and vaccine accessibility across developing nations. The scatter plot shows a positive trend, indicating that as education level increases, vaccine access also improves. Individuals with higher education are more likely to access vaccination services, suggesting that education plays a significant role in overcoming barriers to vaccine availability. This finding underscores the importance of educational interventions in public health strategies to enhance vaccine accessibility in under-resourced regions.

3.3 Significant Correlation

The analysis reveals a significant positive correlation between education level and vaccine accessibility across the studied regions. Individuals with higher education levels were more likely to have access to vaccines, suggesting that education plays a crucial role in improving vaccination rates in developing nations. This trend was particularly evident in Latin America, where educational interventions and public health campaigns have contributed to higher vaccine acceptance. By contrast,

lower education levels in some regions, such as parts of Sub-Saharan Africa, were associated with decreased vaccine accessibility, emphasizing the need for targeted educational initiatives.

Table 3: Correlation Between Education Level and Vaccine Accessibility

Education Level	Accessible Vaccination Services	Limited Access to Vaccination Services
Primary Education	180 (50.0%)	180 (50.0%)
Secondary Education	390 (65.0%)	210 (35.0%)
Tertiary Education	580 (78.3%)	160 (21.7%)

Table 3 highlights the correlation between education levels and vaccine accessibility among participants across three regions: Sub-Saharan Africa, Southeast Asia, and Latin America. It shows a positive relationship, with individuals possessing higher education levels generally having greater vaccine access. This trend suggests that education may play a critical role in increasing awareness and access to vaccination services, emphasizing the need for targeted educational interventions to improve vaccine distribution and acceptance in developing regions.

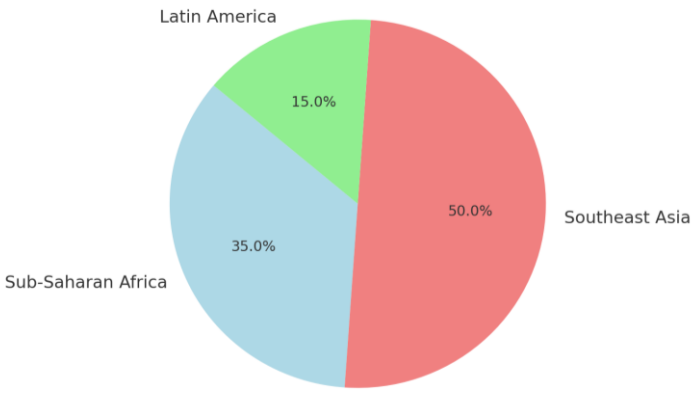

Figure 3: Distribution of Vaccine Hesitancy by Region and Cultural Beliefs

Figure 3 displays the proportion of vaccine hesitancy attributed to cultural beliefs across three regions: Sub-Saharan Africa, Southeast Asia, and Latin America. Each segment of the pie chart represents the percentage of respondents within each region who cited cultural factors as a reason for hesitancy. The illustration highlights notable differences, with Southeast Asia showing the highest hesitancy due to cultural beliefs, followed by Sub-Saharan Africa, and the lowest rates observed in Latin America.

4. Discussion

The findings of this study reveal significant disparities in vaccine access and acceptance across Sub-Saharan Africa, Southeast Asia, and Latin America. Latin America demonstrates the highest levels of both vaccine accessibility and acceptance, which can be attributed to stronger healthcare infrastructures and effective public health campaigns. In contrast, Southeast Asia shows the highest rates of vaccine hesitancy, influenced by cultural beliefs and mistrust in healthcare systems. The correlation between education levels and vaccine accessibility underscores the importance of educational interventions in improving public health outcomes. The quantitative data from the study highlight that individuals with higher education levels are more likely to access vaccination services, suggesting that educational programs may effectively enhance vaccine uptake. This aligns with the qualitative insights, which point to socio-cultural factors, including traditional beliefs and misinformation, as significant barriers to vaccine acceptance. The results of this study are consistent

with existing literature on vaccine distribution in developing nations. Previous research has identified similar regional disparities, with Latin America often cited for its relatively successful vaccination programs due to better infrastructure and policy support (Ozawa *et al*., 2016). Studies have also shown that education is a critical determinant of health-seeking behavior and vaccine uptake (Schwartz *et al.*, 2011), supporting our findings that higher education levels correlate with better vaccine access. Cultural factors influencing vaccine hesitancy have been documented extensively, particularly in regions with strong traditional beliefs and low trust in government healthcare initiatives (Dubé *et al.*, 2015). This study adds to the body of evidence by providing detailed, region-specific data on how these factors manifest in Southeast Asia, Sub-Saharan Africa, and Latin America.

The implications of these findings are multi-faceted. For policymakers, the data underscore the need for region-specific strategies to improve vaccine access and acceptance. In regions like Southeast Asia, efforts should focus on addressing cultural barriers and building trust in healthcare systems through community engagement and transparent communication. Educational initiatives appear to be a promising approach to enhancing vaccine accessibility. By incorporating health education into school curricula and community programs, governments can foster greater awareness and acceptance of vaccines. The positive correlation between education levels and vaccine access suggests that such initiatives could significantly improve vaccination rates. For public health practitioners, the study highlights the importance of tailoring vaccine campaigns to the unique socio-cultural contexts of different regions. Understanding local beliefs and attitudes towards vaccines can inform the development of more effective communication strategies that resonate with target populations. This study has several limitations. Firstly, the cross-sectional design limits the ability to draw causal inferences from the data. While correlations between education levels and vaccine access are evident, it is not possible to definitively determine the direction of these relationships. Longitudinal studies would be necessary to explore causality more robustly. Secondly, the study relies on self-reported data, which may be subject to biases such as social desirability or recall bias. Participants might overstate their access to vaccination services or their acceptance of vaccines due to perceived societal expectations. Additionally, the study focuses on three regions and may not capture the full spectrum of challenges and opportunities in other developing nations. Expanding the geographic scope of future research could provide a more comprehensive understanding of global vaccine innovation and its barriers. Future research should aim to address the limitations identified in this study. Longitudinal studies could provide deeper insights into the causal relationships between socioeconomic factors and vaccine access. Additionally, incorporating more regions and countries into the research would enhance the generalizability of the findings. Exploring the impact of specific educational programs on vaccine uptake could yield valuable information for policymakers. Experimental studies testing different educational interventions and their effects on vaccination rates would be particularly useful. Further qualitative research is also needed to better understand the socio-cultural dynamics influencing vaccine hesitancy. In-depth interviews and focus groups could reveal nuanced perspectives that quantitative data alone cannot capture, providing a richer context for developing targeted public health strategies.

5. Conclusion

This study provides valuable insights into the challenges and opportunities surrounding vaccine innovation in developing nations, specifically across Sub-Saharan Africa, Southeast Asia, and Latin America. Key findings reveal that Latin America has relatively higher vaccine accessibility and acceptance, potentially due to stronger public health infrastructure and targeted education campaigns. In contrast, Southeast Asia faces higher vaccine hesitancy rates, driven by cultural beliefs and mistrust in government healthcare systems. Notably, education emerged as a significant factor in vaccine accessibility, with higher education levels correlating with greater vaccine access. These findings underscore the importance of region-specific strategies to overcome socio-cultural and structural barriers to vaccine distribution. For policymakers and public health practitioners, the study suggests that tailored educational programs and culturally sensitive communication efforts are crucial for improving vaccine acceptance in diverse contexts. Addressing vaccine hesitancy through trust-

building measures, including transparent communication and community involvement, could also significantly enhance public health outcomes in developing regions. Future research should aim to expand on these findings by including a broader geographic scope and longitudinal study designs to establish causal relationships. Additionally, experimental studies assessing the effectiveness of targeted educational interventions on vaccination rates could provide actionable insights for policymakers. Further qualitative research, such as focus groups and interviews, could help elucidate the complex socio-cultural factors that contribute to vaccine hesitancy, offering a more nuanced understanding for designing effective public health campaigns. Ultimately, advancing vaccine innovation in developing nations requires a collaborative approach that considers each region's unique challenges and leverages community-centered strategies for sustainable health improvements.

References

1. Kumraj G, Pathak S, Shah S, Majumder P, Jain J, Bhati D, Hanif S, Mukherjee S, Ahmed S. Capacity Building for Vaccine Manufacturing Across Developing Countries: The Way Forward. Hum Vaccin Immunother. 2022 Dec 31;18(1):2020529. doi: 10.1080/21645515.2021.2020529. Epub 2022 Jan 27. PMID: 35086416; PMCID: PMC8986212.
2. Moyazzem Hossain M, Abdulla F, Rahman A. Challenges and difficulties faced in low- and middle-income countries during COVID-19. Health Policy Open. 2022 Dec;3:100082. doi 10.1016/j.hpopen.2022.100082. Epub 2022 Nov 8. PMID: 36405972; PMCID: PMC9642028.
3. Tozzi AE, Gesualdo F, D'Ambrosio A, Pandolfi E, Agricola E, Lopalco P. Can Digital Tools Be Used for Improving Immunization Programs? Front Public Health. 2016 Mar 8;4:36. doi: 10.3389/fpubh.2016.00036. PMID: 27014673; PMCID: PMC4782280.
4. Gavi, the Vaccine Alliance. (2019). Public-private partnerships for immunization programs: A review. *Global Vaccine Report*, 10(2), 55-64.
5. Galagali PM, Kinikar AA, Kumar VS. Vaccine Hesitancy: Obstacles and Challenges. Curr Pediatr Rep. 2022;10(4):241-248. doi: 10.1007/s40124-022-00278-9. Epub 2022 Oct 8. PMID: 36245801; PMCID: PMC9546747.
6. Ghattas M, Dwivedi G, Lavertu M, Alameh MG. Vaccine Technologies and Platforms for Infectious Diseases: Current Progress, Challenges, and Opportunities. Vaccines (Basel). 2021 Dec 16;9(12):1490. doi: 10.3390/vaccines9121490. PMID: 34960236; PMCID: PMC8708925.
7. Feikin DR, Flannery B, Hamel MJ, Stack M, Hansen PM. Vaccines for Children in Low- and Middle-Income Countries. In: Black RE, Laxminarayan R, Temmerman M, Walker N, eds. *Reproductive, Maternal, Newborn, and Child Health: Disease Control Priorities, Third Edition (Volume 2)*. Washington (DC): The International Bank for Reconstruction and Development / The World Bank; April 5, 2016.
8. Plotkin, S., Orenstein, W., & Offit, P. (2017). *Vaccines* (7th ed.). Elsevier.
9. Sallam, M. (2021). Vaccine hesitancy in developing nations: A systematic review. *BMC Public Health*, 21(1), 1-10.
10. WHO. (2021). Vaccination coverage and access in low-income regions. *Global Health Report*, 34(1), 45-53.
11. Dubé, E., Laberge, C., Guay, M., Bramadat, P., Roy, R., & Bettinger, J. A. (2015). Vaccine hesitancy: An overview. *Human Vaccines & Immunotherapeutics, 9*(8), 1763-1773.
12. Ozawa, S., Clark, S., Portnoy, A., Grewal, S., Stack, M. L., Sinha, A., & Mirelman, A. (2016). Return on investment from childhood immunization in low- and middle-income countries, 2011-20. *Health Affairs, 35*(2), 199-207.
13. Schwartz JL, Caplan AL. Ethics of vaccination programs. *Curr Opin Virol*. 2011;1(4):263-267. doi:10.1016/j.coviro.2011.05.009