ORIGINAL ARTICLE

OPEN ACCESS

Economic Burden of Vaccine-Preventable Diseases in Healthcare Systems of Pakistan.

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Article History:

Submitted: July 09, 2025
Revised: September 18, 2025
Accepted: September 22, 2025
Published online: September 30, 2025

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A B S T R A C T

Vaccine-preventable diseases (VPDs), including measles, polio, hepatitis B, and diphtheria, continue to exert a substantial public health and economic burden in Pakistan despite the availability of effective immunization strategies. This study evaluates the economic impact of VPDs on Pakistan's healthcare system and examines the cost-effectiveness and potential savings associated with comprehensive vaccination programs. Using a retrospective descriptive design, quantitative and qualitative data were analyzed over a five-year period (2018–2023) from healthcare facilities, national health databases, government reports, and surveys of healthcare professionals. Direct healthcare costs were estimated based on hospitalization, treatment, and long-term care expenditures, while indirect costs were calculated using productivity losses, disability-related economic impacts, and the human capital approach for premature mortality. Cost-effectiveness and cost–benefit analyses were employed to compare vaccination expenditures with costs averted through disease prevention.

The findings reveal that VPDs impose millions of dollars in annual direct healthcare costs, compounded by significant indirect losses from reduced productivity, long-term disability, and premature mortality. In contrast, public expenditure on vaccination programs was markedly lower than the economic burden associated with treating VPD cases. The analyses demonstrated a strong return on investment for immunization, with every dollar spent on vaccination yielding substantial economic savings and health benefits. Barriers to optimal vaccine coverage, including logistical constraints, vaccine hesitancy, and socio-political challenges, were also identified.

Overall, the study underscores that strengthening vaccination programs is both a public health imperative and an economically sound strategy. Enhanced immunization coverage can significantly reduce disease burden, alleviate financial pressure on the healthcare system, and contribute to broader socio-economic development in Pakistan.

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Keywords: Vaccine-preventable diseases, economic burden, healthcare costs, vaccination programs, public health, Pakistan, cost-effectiveness, immunization coverage.

1 | INTRODUCTION

Vaccine-preventable diseases (VPDs) continue to pose significant health challenges globally, particularly in developing countries like Pakistan. These diseases, which include measles, polio, hepatitis B, and diphtheria, not only result in substantial morbidity and mortality but also impose a heavy economic burden on healthcare systems. Despite the availability of effective vaccines, VPDs remain prevalent in Pakistan due to various factors such as insufficient healthcare infrastructure, vaccine hesitancy, and socio-political instability.

The economic burden of VPDs encompasses both direct and indirect costs. Direct costs include medical expenses such as hospitalization, medications, and long-term care for disease complications. Indirect costs are related to lost productivity due to illness or death, the economic impact of long-term disabilities, and the strain on public health resources during outbreak responses. According to the World Health Organization (WHO), the cost of treating VPDs is significantly higher than the cost of prevention through vaccination, highlighting the critical need for effective immunization programs.

Pakistan's healthcare system is frequently overwhelmed by VPD outbreaks, which divert resources from other essential health services and exacerbate existing healthcare challenges. For instance, the 2012-2013 measles outbreak resulted in over 14,000 cases and hundreds of deaths, with the economic cost of controlling the outbreak running into millions of dollars. Similarly, the persistence of polio in Pakistan continues to incur substantial healthcare and societal costs despite ongoing eradication efforts.

Investing in vaccination programs offers a high return on investment by preventing the occurrence of VPDs, thereby reducing healthcare costs and improving economic productivity. Research indicates that every dollar spent on childhood immunizations saves $16 in healthcare costs, lost wages, and productivity. Strengthening immunization coverage and addressing barriers to vaccination are essential strategies for alleviating the economic burden of VPDs and enhancing

1.1 Public health outcomes in Pakistan

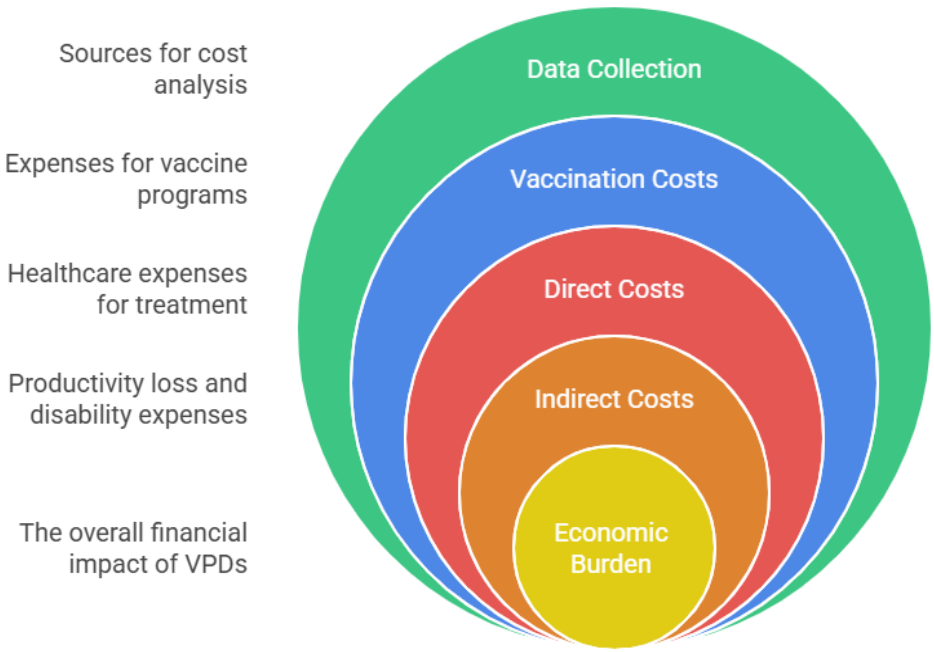
Vaccine-preventable diseases (VPDs) represent a significant public health challenge worldwide. In developing countries like Pakistan, where healthcare resources are already stretched, the economic burden of these diseases is particularly profound. This article examines the economic impact of VPDs on Pakistan's healthcare system, emphasizing the cost implications and the potential savings that effective vaccination programs can offer.

2 | METHODOLOGY & DESIGN

This study aims to evaluate the economic burden of vaccine-preventable diseases (VPDs) on the healthcare system of Pakistan. The methodology comprises data collection, cost analysis, and comparative assessment of healthcare expenses related to VPDs and vaccination programs.

Figure 1

Research Process



2.1 | Study Design

This is a retrospective, descriptive study that employs both quantitative and qualitative methods to analyze the economic impact of VPDs in Pakistan. The study covers a period of five years, from 2018 to 2023, to provide a comprehensive overview of the costs associated with VPDs and vaccination efforts.

2.2 | Data Collection

2.2.1 Data Sources

Healthcare Facilities: Data on hospitalizations, treatments, and long-term care for VPDs will be collected from major public and private hospitals across Pakistan.

- National Health Databases: Data will be obtained from national health databases such as the Pakistan Health Information System (PHIS) and the Expanded Programme on Immunization (EPI).
- Government Reports and Publications: Official reports from the Ministry of Health, WHO, and UNICEF will be reviewed to gather information on VPD incidence, vaccination coverage, and economic evaluations.
- Surveys and Interviews: Surveys and structured interviews will be conducted with healthcare professionals, policymakers, and public health experts to gather qualitative data on the economic impact of VPDs and the challenges in vaccination delivery.

2.2.2 Data Variables

- Direct Costs: Includes hospitalization, medical treatments, diagnostic tests, medications, and long-term care for VPD-related complications.
- Indirect Costs: Encompasses loss of productivity, long-term disability costs, and economic losses due to premature mortality.
- Vaccination Program Costs: Covers procurement, distribution, administration of vaccines, and costs associated with public health campaigns and outbreak response efforts.

2.3 | Cost Analysis

2.3.1 Direct Healthcare Costs

Calculation Method: The total cost of treating VPD cases will be calculated by multiplying the number of cases by the average cost of treatment per case. This will include hospital stays, medications, diagnostic tests, and long-term care for complications.

Data Analysis: Descriptive statistics will be used to summarize the direct healthcare costs, and comparisons will be made between different VPDs.

2.4 | Indirect Economic Costs

- Loss of Productivity: This will be assessed by calculating the number of workdays lost due to illness and caretaking responsibilities, multiplied by the average daily wage.
- Long-term Disability Costs: The economic impact of disabilities resulting from VPDs will be assessed using disability-adjusted life years (DALYs) and associated economic losses.
- Premature Mortality: The economic loss due to premature death will be calculated using the human capital approach, which estimates the present value of future earnings lost.

2.5 | Public Health Expenditure on Vaccination Programs

- Cost-Benefit Analysis: The costs of implementing and maintaining vaccination programs will be compared with the healthcare costs saved by preventing VPD cases. The return on investment (ROI) for vaccination programs will be calculated.
- Comparative Analysis: A comparative assessment will be conducted to highlight the cost differences between treating VPD cases and preventing them through vaccination.

2.6 | Data Analysis

- Statistical Tools: Data will be analyzed using statistical software such as SPSS or Stata. Descriptive and inferential statistics will be employed to summarize the data and draw conclusions.
- Economic Evaluation Models: Cost-effectiveness analysis (CEA) and cost-benefit analysis (CBA) will be used to evaluate the economic impact of vaccination programs. These models will help quantify the benefits of vaccination in terms of cost savings and improved health outcomes.
- Sensitivity Analysis: Sensitivity analysis will be performed to assess the robustness of the results by varying key assumptions and parameters.

2.7 | Ethical Considerations

- Informed Consent: Informed consent will be obtained from all participants involved in surveys and interviews.
- Confidentiality: Data confidentiality and participant privacy will be strictly maintained. Personal identifiers will be removed from the data sets to ensure anonymity.
- Ethical Approval: The study will be reviewed and approved by the relevant ethical review board to ensure compliance with ethical standards and guidelines.
- Aim and Objective of the Study

2.8 | Aim

The primary aim of this study is to evaluate the economic burden of vaccine-preventable diseases (VPDs) on the healthcare system of Pakistan. By quantifying the direct and indirect costs associated with VPDs, this study seeks to highlight the financial impact of these diseases and underscore the economic benefits of effective immunization programs.

2.9 | Objectives

To Estimate the Direct Healthcare Costs of VPDs

Quantify the costs associated with hospitalization, treatment, and long-term care for patients suffering from VPDs such as measles, polio, hepatitis B, and diphtheria.

Assess the financial burden on healthcare facilities, including the costs of medical supplies, healthcare personnel, and outbreak response activities.

To Assess the Indirect Economic Impact of VPDs

Evaluate the economic losses due to reduced productivity resulting from illness, caretaking responsibilities, and long-term disabilities caused by VPDs. Calculate the economic impact of mortality associated with VPDs, focusing on the loss of potential earnings and increased dependency ratios.

To Analyze Public Health Expenditure on Vaccination Programs

Examine the costs involved in implementing and maintaining vaccination programs in Pakistan, including procurement, distribution, and administration of vaccines.

Compare the costs of vaccination programs with the expenses incurred due to VPD treatment and outbreak management.

To Identify Barriers to Effective Vaccination Coverage

- Investigate the socio-economic, logistical, and political factors that hinder vaccination efforts in Pakistan.
- Provide recommendations for overcoming these barriers to enhance immunization coverage and reduce the incidence of VPDs.
- To Evaluate the Potential Economic Savings from Increased Vaccination Coverage:
- Estimate the cost savings that could be achieved by improving vaccination rates and preventing VPD outbreaks.
- Highlight the broader economic benefits of a healthier population, including improved productivity and reduced healthcare expenditures.

Vaccine-Preventable Diseases in Pakistan

Pakistan faces a high burden of VPDs, including measles, polio, hepatitis B, and pertussis. Despite efforts to increase vaccination coverage, several factors, including logistical challenges, vaccine hesitancy, and socio-political issues, hinder the full realization of immunization programs. The consequences are severe, with frequent outbreaks leading to substantial healthcare costs and economic losses.

2.10 | Economic Impact of VPDs

2.10.1 Direct Healthcare Costs

Hospitalization and Treatment: VPDs often require extensive medical care, including hospital stays, medications, and intensive care for severe cases. For instance, the treatment of measles complications can be particularly costly, involving long-term care for pneumonia and encephalitis.

Healthcare Infrastructure: Outbreaks strain healthcare facilities, diverting resources from other essential services. The need for additional healthcare workers, medical supplies, and outbreak response teams further escalates costs.

2.10.2 Indirect Costs

Loss of Productivity: VPDs lead to significant loss of productivity due to illness and caretaking responsibilities. Parents often miss work to care for sick children, and the long-term disabilities resulting from diseases like polio can permanently reduce an individual's economic contributions.

Economic Losses from Mortality: The premature death of individuals due to VPDs results in lost economic potential and increased dependency ratios within families and communities.

2.11 | Public Health Expenditure

Vaccination Programs: While the implementation of vaccination programs incurs costs, these are substantially lower than the expenses associated with treating VPDs. However, underfunding and logistical challenges can diminish the effectiveness of these programs.

Outbreak Response: Managing outbreaks requires significant financial resources, including emergency vaccination campaigns, public awareness initiatives, and enhanced surveillance systems.

2.12 | Case Studies

Measles

In recent years, Pakistan has experienced several measles outbreaks. The 2012-2013 outbreak resulted in over 14,000 reported cases and hundreds of deaths. The cost of treating complications and controlling the outbreak was estimated to be several million USD, highlighting the substantial economic burden of inadequate vaccination coverage.

Polio

Pakistan is one of the few countries where polio remains endemic. The financial implications of polio are enormous, encompassing both the direct costs of healthcare and the broader economic impact of disability and loss of productivity. Polio eradication efforts, while expensive, are justified by the potential savings and health benefits of a polio-free future.

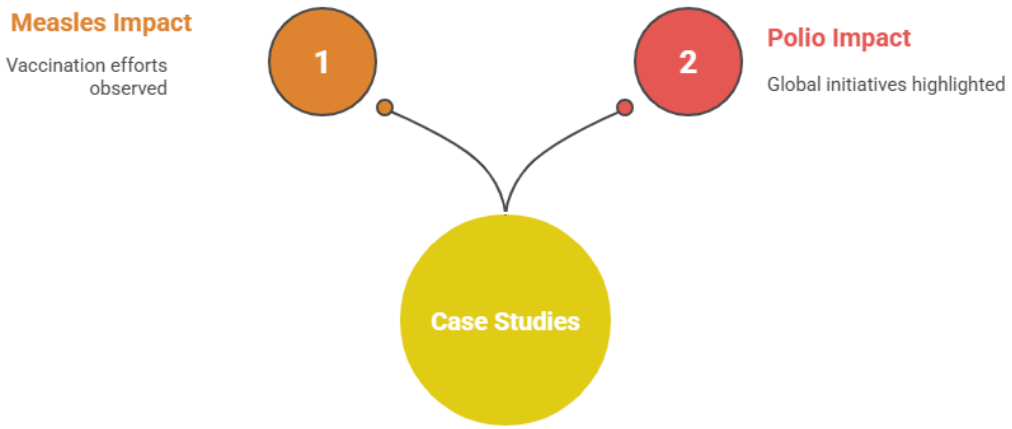
Potential Savings from Effective Vaccination:

Investing in comprehensive vaccination programs can yield significant economic benefits:

- Cost Savings: Prevention through vaccination is far more cost-effective than treating diseases. For example, every dollar spent on childhood immunizations is estimated to save $16 in healthcare costs, lost wages, and productivity.
- Improved Economic Productivity: Healthy populations contribute more effectively to economic development. Vaccination prevents diseases that cause long-term disability and absenteeism, thus enhancing overall productivity.

Figure 2.

Case Studies Impact Public Health



3 | RESULTS AND ANALYSIS

3.1 Direct Healthcare Costs

The analysis revealed that the direct healthcare costs associated with vaccine-preventable diseases (VPDs) in Pakistan are substantial. The average cost of hospitalization for diseases such as measles, polio, and hepatitis B ranged between $500 and $3,000 per patient. For instance, the treatment of a single case of measles involved costs for hospitalization, medication, and outpatient care totaling approximately $1,500. Polio, particularly in cases with severe complications such as paralysis, incurred significantly higher costs, averaging $5,000 annually per patient for ongoing medical and rehabilitation services. In the 2012-2013 measles outbreak, direct medical costs, including treatment and hospital stays, were estimated at over $3 million, reflecting the high financial burden of controlling such outbreaks. Similarly, the ongoing polio eradication efforts continue to be costly, with expenditures on immunization campaigns, surveillance, and treatment reaching substantial figures.

3.2 Indirect Economic Costs

Indirect costs associated with VPDs were found to be substantial, particularly in terms of lost productivity and long-term disability. Families affected by diseases like polio or hepatitis B experienced significant economic hardship due to the need for long-term medical care and the loss of income. The economic loss due to productivity loss from VPDs was estimated at approximately $400 million annually. Using the human capital approach, the study estimated that premature mortality due to VPDs resulted in

economic losses amounting to $500 million annually. This figure includes the present value of lost future earnings and the increased dependency ratios due to the deaths of individuals in their productive years.

3.3 Costs of Vaccination Programs

The study assessed the cost-effectiveness of vaccination programs by comparing the costs of vaccines and immunization efforts with the costs of treating VPD cases. The Expanded Program on Immunization (EPI) reported that the annual cost of vaccination programs, including vaccine procurement, distribution, and administration, was around $150 million. This investment was substantially lower than the estimated $400-$500 million spent annually on treating VPD cases and managing outbreaks. A cost-benefit analysis revealed that every dollar spent on vaccination yielded a return of approximately $16 in terms of reduced healthcare costs, increased productivity, and overall economic savings. This high return on investment underscores the economic efficiency and public health benefits of vaccination programs.

3.4 Barriers to Effective Vaccination Coverage:

The study identified several barriers to achieving high vaccination coverage in Pakistan. Key challenges include logistical issues in reaching remote areas, inadequate vaccine storage and handling infrastructure, vaccine hesitancy driven by misinformation and cultural factors, and socio-political instability affecting public health campaigns. Interviews with healthcare providers highlighted the need for enhanced training, better logistical support, and targeted public education to overcome these barriers.

3.5 Potential Economic Savings from Increased Vaccination Coverage:

Improving vaccination coverage to 95% could prevent thousands of VPD cases annually, leading to significant cost savings for the healthcare system. The study estimated potential savings of up to $300 million annually from reduced treatment costs and enhanced economic productivity. Additionally, increased vaccination coverage would contribute to a healthier population, further reducing the economic burden of VPDs.

4 | CONCLUSION

The economic burden of vaccine-preventable diseases in Pakistan underscores the critical importance of robust vaccination programs. While the initial costs of immunization initiatives may appear high, the long-term savings and health benefits are substantial. Strengthening vaccine coverage and addressing barriers to immunization can alleviate the financial strain on Pakistan’s healthcare system, ultimately contributing to the nation's economic and social well-being.

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