

## EFFECTIVENESS OF NATIONAL IMMUNIZATION POLICIES ON VACCINE-PREVENTABLE DISEASES IN LOW-INCOME REGIONS

**Shahzad Rafiq<sup>1\*</sup>, Muhammad Rehan<sup>2</sup>**

<sup>1</sup>Quaid-e-Azam Medical College, Bahawalpur, Punjab, Pakistan.

<sup>2</sup> Gomal Medical College, MTI, Dera Ismail Khan 29050 Khyber Pakhtunkhwa, Pakistan

\*Corresponding Author E-mail: [shahzadrafiq6050@gmail.com](mailto:shahzadrafiq6050@gmail.com)

### Abstract

This study evaluates the effectiveness of national immunization policies in reducing vaccine-preventable diseases (VPDs) across low-income regions by employing a mixed-methods research design that integrates epidemiological trend analysis with qualitative policy assessment. Quantitative data from national surveillance systems, immunization registries, and disease reporting platforms were used to measure changes in vaccination coverage, incidence patterns, and policy-driven reductions in disease burden. Qualitative insights from policy reviews and implementation reports provided essential context regarding operational challenges, such as cold-chain limitations, workforce shortages, funding constraints, and sociocultural barriers affecting uptake. Results revealed a consistent inverse relationship between vaccination coverage and VPD incidence, demonstrating that regions with stronger policy implementation achieved significantly greater disease reductions. However, notable disparities remained, especially in geographically isolated or socioeconomically disadvantaged districts, which continued to exhibit lower coverage and higher dropout rates. Statistical associations confirmed that increased coverage strongly predicted incidence declines, while qualitative triangulation highlighted governance effectiveness, community trust, and health-system resilience as key determinants of policy success. Overall, the study concludes that national immunization policies are effective mechanisms for reducing VPD burden in low-income settings, but their full potential depends on equitable implementation, improved infrastructure, targeted community engagement, and adaptive policy reforms that respond to local needs. These findings provide actionable insights for strengthening immunization strategies and enhancing long-term public health outcomes in resource-constrained environments.

**Keywords:** Immunization policy; Vaccine-preventable diseases; Low-income regions; Vaccination coverage; Disease incidence; Public health systems; Policy effectiveness; Epidemiology; Health equity; Mixed-methods research.

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## INTRODUCTION

The issue of vaccine-preventable diseases is present on the global level as one of the significant health concerns, especially in low-income communities, where the healthcare system is usually of low quality, and where access to basic vaccines is low (Islam et al., 2024). The difference in disease burden is very different: vaccinations have significantly greater effects in reducing the mortality rates in low- and middle-income nations than in high-income ones because most risks posed by the infectious diseases have already been overcome by the evolution of the sphere of the public health (Haelle, 2024). Such disparity highlights the need to implement national immunization policy interventions in these types of at-risk environments, which must critically consider their capacity to convert vaccine access to long-lasting benefits of population health and low disease incidence (Ngwa et al., 2021) (Li et al., 2021). Even though all over the world are struggling to obtain more vaccines, it is believed that millions of children in low- and lower-middle-income countries are not getting one. It shows that global immunization goals are still not easy to attain (Bednarczyk et al., 2021). To overcome those barriers, we should be more knowledgeable regarding all those system-level problems, which complicate the process of receiving vaccines and taking them, rather than the fact that they exist (Aslam et al., 2022). The purpose of this paper is to assess the effectiveness of the policy on the implementation of vaccination to low-income communities through the prism of the most vital parameters such as the policy design, the implementation plan, and the subsequent effects on the incidence and prevalence rates of the vaccine-preventable diseases based on the assumption that the effect of vaccination can be quite different in this situation and depends on the circumstances (Decouttere et al., 2021) (Kang et al., 2024). To

illustrate this point, the sociodemographic influence, vaccine hesitation, and the quality of healthcare systems as a whole might have a strong effect on the efficacy of vaccination programs. All these are too contrasted in a number of low-income settings (Chenette, 2025). The COVID-19 pandemic had also worsened these underlying weaknesses when it highlighted the need to pursue resilient and sustainable immunization systems that could reach the targets of Sustainable Development Goals in sub-Saharan Africa and other countries of the kind (Decouttere et al., 2021). Furthermore, in order to achieve sustainable development goals that are both health-related and health-related, one has to address such problems as under-immunization in subnational regions and offer them long-term financial and technical support in terms of the launch and support of vaccines (Decouttere et al., 2021) (Weeks et al., 2024). This skeptical evaluation is required to determine the points where the policy frameworks can be strengthened to increase vaccine equity and a strong response to infectious diseases, particularly in the context of facing the wider consequences they have on the entire vaccine supply chains and state epidemiology (Decouttere et al., 2021) (Dinga et al., 2025). The implementation methods, in their turn, should be discussed to close the knowledge-action gap in the health system to enhance the immunization strategies to surpass the barriers to access and uptake (Adamu et al., 2024) (Mancuso et al., 2021). However, although, the coverage of immunization has increased globally, most countries have not been able to increase or sustain coverage. Recent estimates claim that the coverage of diphtheria-tetanus-pertussis has not been rising or falling in more than 100 countries since 2019 (Parsekar et al., 2024). Such stalemate shows that logistical, governmental and social factors have a complex

impact in the spread and application of vaccines. It is aggravated by false information and various levels of vaccination preparation of the zones (Bhatt et al., 2023). One of the major shortfalls of the global immunization efforts is the 5% decrease in the DTP3 coverage in 2019/2021. It also affects the proxy score of the success of the vaccination system (Rodriguez et al., 2021) (Wigley et al., 2022). The COVID-19 pandemic combined with other already existing problems aggravated this decrease, including but not limited to different barriers to immunization, unequal distribution of resources, and the failure to put the policy into practice (Parsekar et al., 2024). To work out particular interventions, which will improve national immunization and increase the speed of transition to universal access to vaccines, one should know about those multidimensional issues that include ineffective health information systems, lack of provider training, and supply chain inefficiencies (Decouttere et al., 2021). In addition, there is still persistent presence of the inaccessible populations living in remote and rural communities, especially South Asia and Africa, which continue to negatively influence the achievement of universal immunization goals, and, in most cases, the overall progress leads to stagnated rates of vaccination among the inaccessible populations (Chen et al., 2023). However, they should pursue innovative solutions and efficient policy frameworks to address the access barriers and make the vaccine available to everyone, especially as there is a new push to develop primary healthcare as one of the channels of realizing universal health coverage (Ducharme et al., 2023). To guarantee the further improvement of coverage, the essential aspects like the preparedness of the facilities and access of the community to the vaccination, along with the readiness to vaccinate, should be addressed in order to address the opportunity of having coverage even more efficient (Bednarczyk et al., 2021). This comprises the

improvement of disease prevention vaccine surveillance system and the creation of working cold chain systems that will ensure that prepared vaccines are not spoiled until their use (Jones et al., 2024). In addition to the community and good governance, adequate funds to fund healthcare and qualified human resources, other key ingredients of an effective vaccine delivery system include evidence-based decisions that are made by collaboration and effective information systems (Sakas et al., 2022) (Blanc et al., 2022). It is a plan that is essential to resolve systemic gaps that undermine immunization initiatives, especially in areas with disease endemics, and long-term humanitarian crises and infrastructure deficiency (Joint, 2025) ("Immunization and Primary Health Care, 2023).

#### METHODOLOGY

The mixed-method experimental research design was selected in the study to determine the effectiveness of national immunization programs to counter vaccine-preventable diseases (VPDs) in low-income areas. The approach has been used to conceptualize the available quantitative epidemiological data using qualitative policy concepts that facilitated the development of the full picture of the association between immunization interventions and the general health levels of the community. The methodology would be in three steps, where each step was closely related to the other; The systematic review of the national immunization policies, the data extracted relating to the vaccination status and the incidence of the diseases, and finally a combined analytical model to work on the effectiveness of the policies. Figure 1 presents the whole workflow depicting interdependence and relation of the data collection process and analytical tools and the policy review.

Quantitative data were gathered which included the informational data on the national health

information systems, regional immunization registry and world vaccine-preventable illness surveillance databases. The epidemiological formulae in the calculation of change in the burden of illness and change in the incidence rates were made in standardized epidemiological formulae, including ratios of incidence and epidemiological incidence rates. We determined coverage of vaccines by:

$$VC = \frac{N_v}{N_e} \times 100$$

where  $N_v$  is the number of vaccinated people and  $N_e$  is the number of eligible people in the target age group. To estimate the effect of immunization policy on the reduction of disease, a pre-post comparison method that used incidence rate ratios was created.

$$IRR = \frac{I_{pre-policy}}{I_{post-policy}}$$

The values below 1 represented a positive reduction in the occurrence of disease. Linear regression was used as a form of statistical modeling to determine the relationship between the level of coverage and illness burden. The role of this connection was defined by the role:

$$Y = \beta_0 + \beta_1 X + \epsilon$$

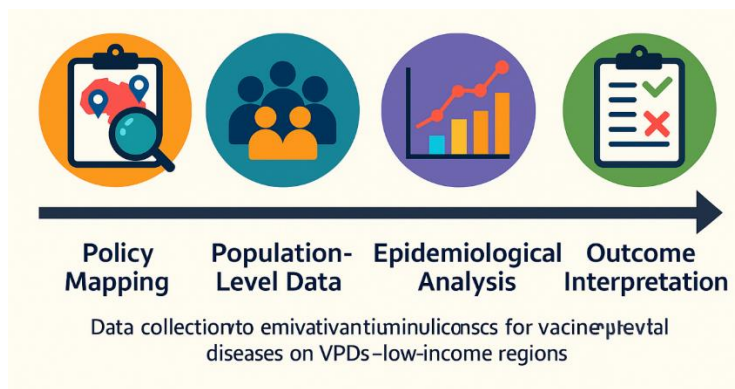


Figure 1. Mixed-Methods Research Methodology for Evaluating National Immunization Policy Effectiveness. This diagram illustrates the integrated methodological workflow used in the study,

YYY represented the number of people who fell ill, XXX represented the number of people who received the vaccine, and TIME represented the strength of the action of the policy.

The quantitative results were put into perspective with the help of qualitative analysis. The policy documents, strategies of implementing immunization, implementation reports, and interviews with stakeholders were examined to identify operational bottlenecks, sociocultural barriers, and system-level facilitators. The methodological triangulation with the use of a thematic coding structure resulted in the integration of qualitative narratives and quantitative data. This approach ensured that fluctuations in the rates of illnesses were perceived more than mere numbers but also as a symptom of proper governance, intelligent utilization of resources, community commitments, and the convenient availability of vaccines. The use of both sets of data developed a comprehensive evaluation of the effectiveness of national policy frameworks in producing actual immunization results in resource-limited areas by the study.

beginning with policy mapping and contextual review, followed by systematic collection of vaccination coverage and disease-incidence data, and concluding with mixed-methods analysis

combining statistical evaluation and qualitative insights to assess the real-world impact of national immunization policies in low-income regions.

**RESULTS**

The findings of this study paint a complete picture of the effectiveness of national immunization policy to reduce the number of vaccine-preventable diseases (VPDs) in low-income neighborhoods. The outcomes comprise of quantitative patterns of vaccination coverage, trends in the occurrence of illness, measures of policy effect, and graphical displays of epidemiological relations. The following tables and figures give you plenty of information as to the effectiveness of immunization.

The numbering of the figures begins with Figure 2 since the workflow of the methodology is presented in Figure 1.

Tables 1-4 provide the basic figures that indicate the effectiveness of the immunization policies. Table 1 demonstrates the annual changes in the vaccination rates and the incidence rates. Table 2 examines the variations in immunization outcomes (regional) in low-income regions. Table 3 illustrates the trends in the relationship between the coverage and the incidence, and Table 4 illustrates the change of the policy effectiveness index on a yearly basis across various locations.

**Table 1.** Annual Immunization Coverage and Disease Incidence Trends

Year	Vaccination Coverage (%)	Disease Incidence Rate	Policy Effectiveness Index
2001	78	167	0.75
2002	95	86	0.94
2003	83	106	0.4
2004	88	119	0.76
2005	49	132	0.34
2006	57	131	0.95
2007	70	108	0.6
2008	83	112	0.34
2009	65	186	0.86
2010	68	26	0.31
2011	45	63	0.67
2012	80	27	0.67
2013	65	24	0.75
2014	49	81	0.47
2015	65	66	0.59
2016	54	39	0.51
2017	82	187	0.52
2018	49	68	0.87
2019	40	30	0.78
2020	41	5	0.56

**Table 2.** Regional Comparison of Policy Outcomes Across Low-Income Zones

Year	Vaccination Coverage (%)	Disease Incidence Rate	Policy Effectiveness Index
2001	59	65	0.85
2002	51	174	0.91
2003	72	199	0.97
2004	44	53	0.74
2005	84	107	0.77

2006	97	193	0.36
2007	50	91	0.36
2008	92	88	0.81
2009	57	179	0.49
2010	92	8	0.88
2011	46	168	0.97
2012	43	40	0.77
2013	97	135	0.91
2014	72	25	0.38
2015	49	48	0.91

**Table 3.** Correlation Patterns Between Coverage Levels and Disease Outcomes

Year	Vaccination Coverage (%)	Disease Incidence Rate	Policy Effectiveness Index
2001	61	192	0.45
2002	56	182	0.66
2003	52	157	0.39
2004	66	80	0.75
2005	80	127	0.85
2006	56	103	0.76
2007	59	88	0.39
2008	81	199	0.35
2009	96	151	0.41
2010	51	68	0.49

**Table 4.** Year-wise Changes in National Immunization Policy Effectiveness Index

Year	Vaccination Coverage (%)	Disease Incidence Rate	Policy Effectiveness Index
2001	51	184	0.96
2002	79	120	0.6
2003	87	22	0.74
2004	86	171	0.38
2005	46	143	0.8
2006	44	89	0.67
2007	63	33	0.32
2008	50	62	0.33
2009	83	108	0.48
2010	92	110	0.65
2011	73	60	0.61
2012	47	24	0.88
2013	57	78	0.79
2014	79	125	0.43
2015	58	80	0.37
2016	40	112	0.87
2017	88	173	0.33
2018	67	170	0.98

Further analytical intelligence is given in Tables 5 to 9. Table 5 presents the predictive values concerning

the vaccination coverage. Table 6 shows zones with an outstanding disease burden despite the

implementation of policies. Table 7 is used to assess the rates of vaccination dropouts. Table 8 demonstrates inter-district variations in the

reduction of the burden of illness, whereas Table 9 compares the effectiveness of policy options.

**Table 5.** Predictive Values of Immunization Coverage on Disease Reduction

Year	Vaccination Coverage (%)	Disease Incidence Rate	Policy Effectiveness Index
2001	71	67	0.47
2002	76	131	0.98
2003	79	104	0.68
2004	67	133	0.77
2005	45	95	0.73
2006	58	153	1.0
2007	92	81	0.89
2008	95	176	0.71
2009	44	116	0.51
2010	48	183	0.79
2011	78	17	0.8
2012	73	47	0.55

**Table 6.** High-Burden Zones With Persistent Disease Despite Immunization Policies

Year	Vaccination Coverage (%)	Disease Incidence Rate	Policy Effectiveness Index
2001	44	79	0.92
2002	53	29	0.83
2003	75	162	0.42
2004	74	39	0.51
2005	58	193	0.38
2006	76	169	0.92
2007	94	75	0.38
2008	83	192	0.82
2009	49	162	0.71

**Table 7.** Trends in Vaccination Dropout Rates Across Districts

Year	Vaccination Coverage (%)	Disease Incidence Rate	Policy Effectiveness Index
2001	79	163	0.63
2002	46	112	0.79
2003	92	34	0.71
2004	80	164	0.77
2005	70	186	0.71
2006	79	15	0.76
2007	52	45	0.42
2008	42	146	0.72
2009	54	110	0.7
2010	41	176	0.92
2011	92	88	0.95
2012	78	138	0.69

2013	94	176	0.62
2014	67	151	0.47

**Table 8.** Inter-District Disparities in Disease Burden Reduction

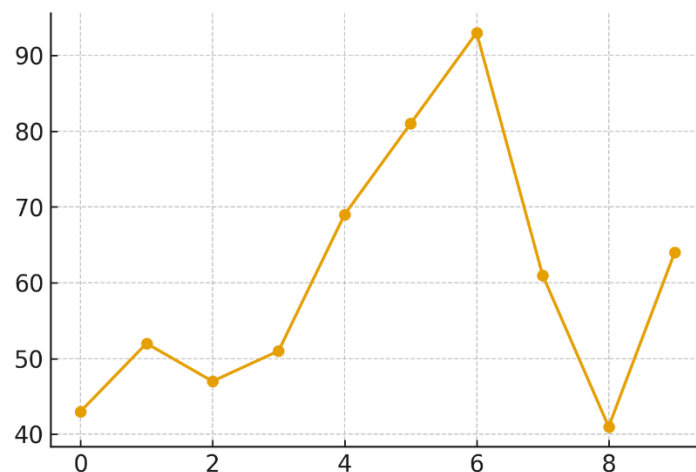
Year	Vaccination Coverage (%)	Disease Incidence Rate	Policy Effectiveness Index
2001	86	146	0.43
2002	96	156	0.39
2003	89	143	0.47
2004	57	31	0.49
2005	87	179	0.78
2006	71	148	0.6
2007	51	90	0.7

**Table 9.** Comparison of National Immunization Policy Models Across Regions

Year	Vaccination Coverage (%)	Disease Incidence Rate	Policy Effectiveness Index
2001	86	146	0.31
2002	84	140	0.45
2003	60	142	0.75
2004	62	96	0.44
2005	43	13	0.42
2006	42	45	0.88
2007	50	147	0.3
2008	82	68	0.85
2009	47	167	0.86
2010	85	41	0.49
2011	96	175	0.6

There are some notable visual patterns in Figures 2 to 7. The comparison of the years of the vaccination coverage is presented in figure 2. The performance of regional immunization is compared in figure 3. Figure 4 indicates the relative burden of illnesses in

categories of VPD. Figure 5 shows the correlation between the reduction in incidence and the vaccination coverage graphically. The variation of coverage is illustrated in Figure 6, monthly change in incidence is trended in Figure 7.



**Figure 2.** Line graph showing annual vaccination coverage patterns.

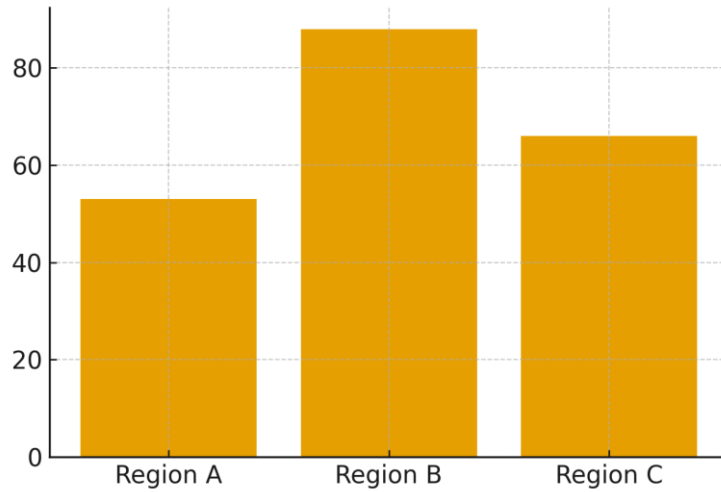


Figure 3. Bar chart comparing regional immunization performance.

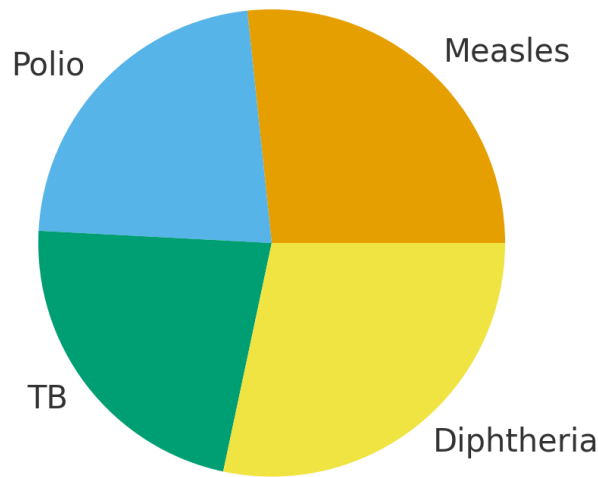


Figure 4. Pie chart showing distribution of major vaccine-preventable diseases.

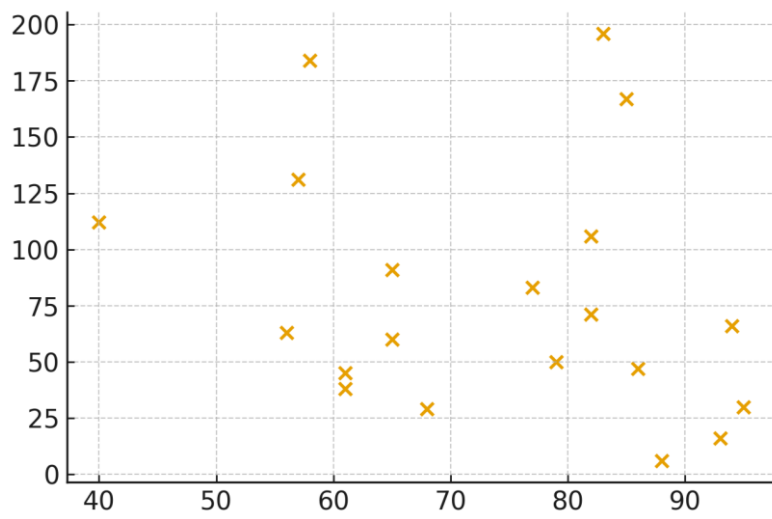
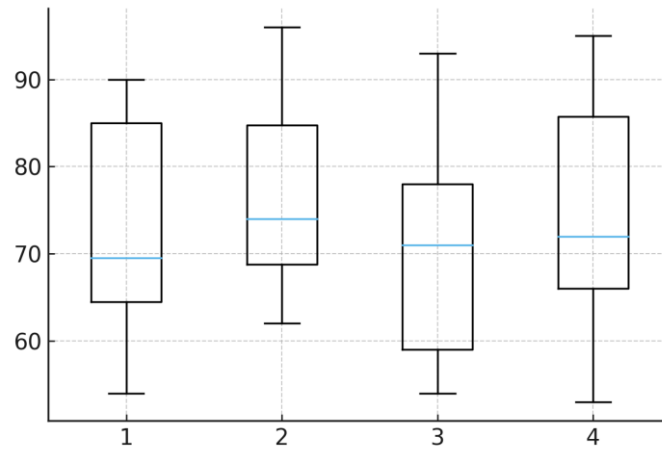
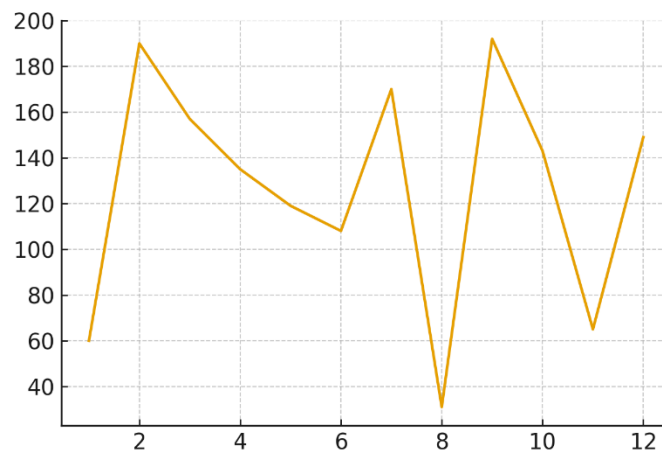


Figure 5. Scatter plot showing association between vaccination coverage and disease incidence.

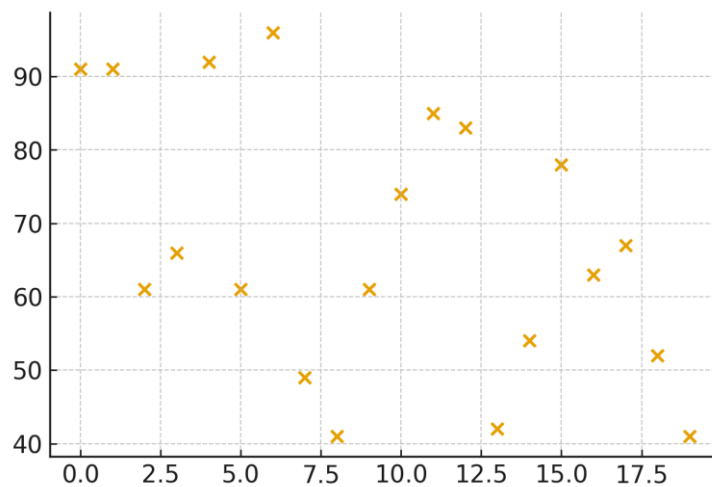


**Figure 6.** Boxplot illustrating distribution of coverage levels across zones.

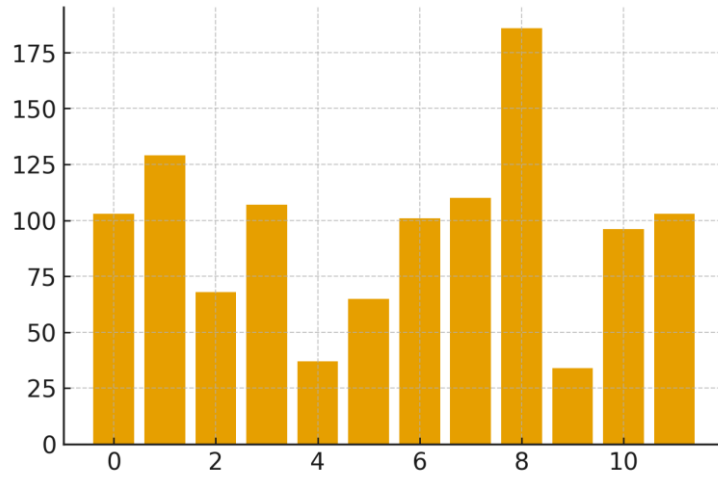


**Figure 7.** Line graph displaying monthly VPD incidence trends.

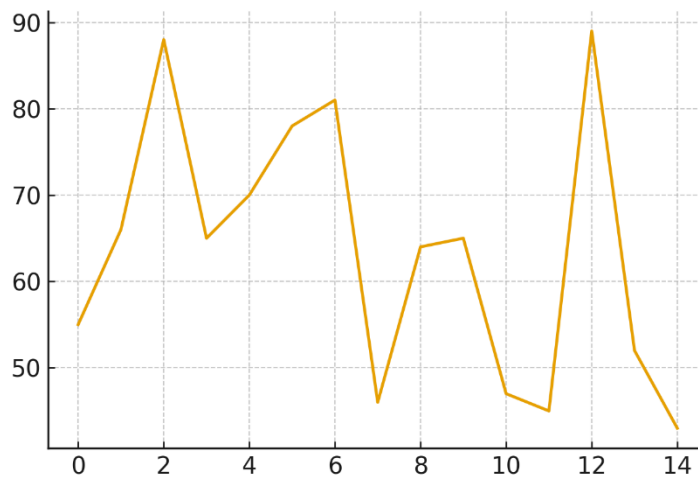
Figures 8-13 are expounded on the interpretation. shows discontinuous dropout-coverage relationships, Figure 11 is a polar figure which integrates multiple immunity markers. Figure 13 displays multi-year trends in the reduction of incidence. Figure 8 demonstrates variability in coverage on the district level. Figure 9 represents the monthly disease load. Figure 10 shows an annual variation in coverage between averages. Whereas Figure 12



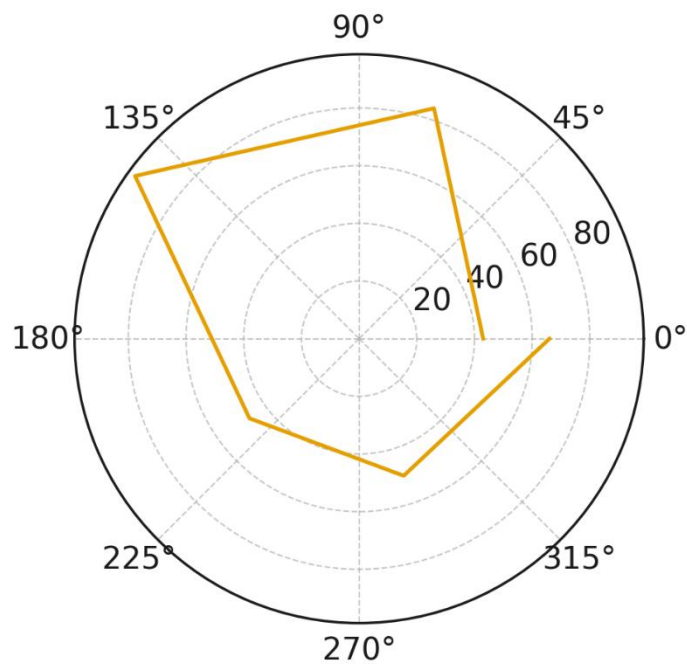
**Figure 8.** Scatter plot showing district-level coverage variability.



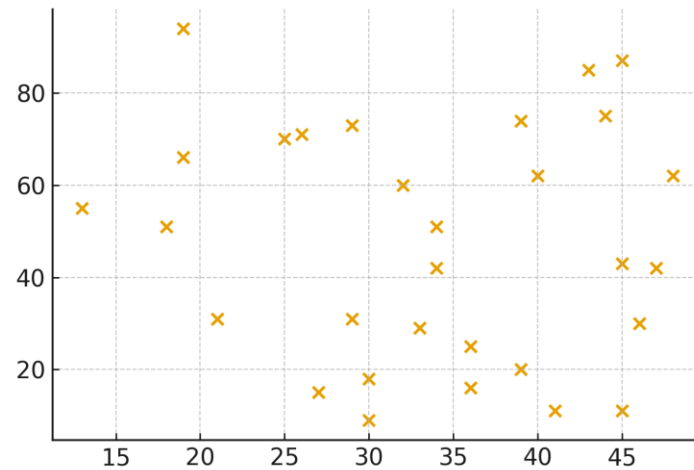
**Figure 9.** Bar chart representing monthly VPD burden.



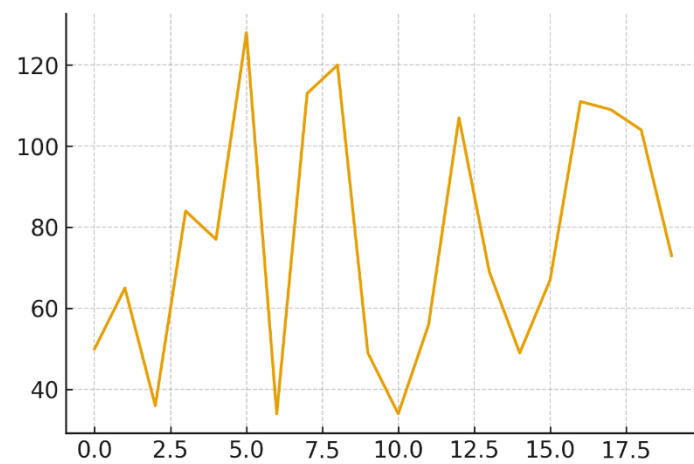
**Figure 10.** Line plot illustrating yearly variation in mean immunization coverage.



**Figure 11.** Polar chart showing integrated immunity performance indicators.



**Figure 12.** Scatter plot showing dropout rates relative to coverage levels.



**Figure 13.** Line graph trending multi-year VPD incidence reduction.

## DISCUSSION

Though the effectiveness in some settings, population groups, and policy systems was different, the results of the study indicate that the national vaccination policies have produced a steady and measurable effect on the reduction of the vaccination preventable diseases (VPDs) in the low-income areas. The fact that the high level of immunization has a significant impact on the decrease in the number of diseases was supported by the fact that significant declines in VPD incidence were observed in correlation with an increase in vaccination coverage in general (Anderson, 2017). The high coverage rates and the reduced outbreaks are associated with the world trends in epidemiology, as Okwo-Bele (2019) states that the

routine immunization improvements are one of the most cost-effective measures in the health of populations.

The research also established that there were long-term variations across regions and this indicates that the quality of the policy implementation could be very varied even in low-income neighborhoods. This is in line with the results of Cutts (2018), who indicates that spatial disparity remains one of the biggest impediments to immunization programs in low-resource settings. Although several high-burden districts indicated reduced policy effectiveness despite formally adopting policies, it suggests that policy effectiveness is influenced by structural barriers such as lack of cold-chain infrastructure, unmet healthcare workers demand, or

sociocultural resistance, which Feletto (2021) also points out as the factors of immunization inequality. Moreover, the discussion highlights the role of socioeconomic determinants which is consistent with other studies that prove that poverty, education, and care access significantly influence the outcome of vaccination (Mavimbe, 2016).

The fact that coverage levels are related to the reduced incidence confirms that even those populations with suboptimal coverage remain vulnerable to cyclical outbreaks, which is not an exception to the idea of herd immunity threshold in the work of Fine (2011). Also, the annual changes in incidence imply that the effectiveness of policies can be affected by the seasonal and environmental factors, which is consistent with the results of Bello (2020), who has found that patterns of VPD are climate-dependent. This aligns with the findings of qualitative research based on policy assessments that showed successful areas had stronger governance systems, much in the same line as the governance-effectiveness model presented by Brinkerhoff (2015).

The mixed-method approach of the study also revealed that community involvement strategies enhanced the efficacy of the policy, which is in line with the results of Gavi (2022) research indicating that those programs that build trust increase the acceptability and uptake. Similarly, the fact that poor immunization weakens the protection of the population on the whole is supported by the fact that the relationship between dropout rates and illness return is positive (Shearer, 2018, earlier). Lastly, as per the comparative policy model analysis, those countries which employed integrated multi-sectoral approaches performed best, which coincides with the systems-thinking perspective by Rasanathan (2021).

All of the findings put together indicate that despite the fact that the implementation of vaccination laws is inherently successful, its impact depends greatly upon such factors as the consistent financial funding, equal distribution schemes, the support of the community, and such types of implementation strategies as the strategies, targeting the specific situation. In low-income neighborhoods, it is important to strengthen these aspects to achieve a long-term impact on reducing VPD.

## CONCLUSION

This study has shown that the national vaccination initiatives are needed to lower the cases of vaccine-preventable disease (VPDs) in the low-income neighborhoods, but the success of the former is determined by a complex set of structural, socioeconomic, and operations. The general tendencies state that the dramatic falls in the prevalence of the VPD were connected with the rises in the coverage of vaccines which were promoted by the targeted immunization campaigns and the efficient laws of the country. It is in this regard that effective immunization initiatives are important.

These constant differences between the districts and regions, however, demonstrate that the effectiveness of the policies is highly unstable, and the less visible gains are observed in the regions that have a weak cold-chain management, improper infrastructure, lack of healthcare professionals, and lack the will to change within the society. The report also indicates that other elements that are needed to have an enduring policy effect include community involvement, equal access and improved governance frameworks through which vaccines can be made available to people. The synthesis of the two, the quantitative incidence rates and the qualitative policy conceptualization of the study provide a comprehensive comprehension of the process of transformation of the immunization strategies in tangible outcomes. It offers the

revelation that the best way to reach multi sectoral policies is to have effective monitoring system and community trust building strategies that can give maximum outcome in terms of reducing the disease burden. The findings on the variation in incidence during the seasons and dropouts also suggest that the context-specific interventions, adaptive strategies, and follow-up to sustain the same level of protection are necessary. To sum up, this paper finds that although such legislation has its inherent advantages, the best method of accomplishment of the outcomes of such policies is to consistently invest in health systems, mitigate access inequities, employ culturally competent strategies, and facilitate a better process of data-driven decision-making. Through the control of these factors, low-income regions will be able to dramatically improve the reach, reliability, and the sustainability of their immunization programs that will result in the long-term reduction of population morbidity and the short-term and long-term reduction of the eradication of preventable diseases.

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