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An Appraisal of Cost Effectiveness of Polio Immunization in North Central Nigeria

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ABSTRACT:
Poliomyelitis remains a persistent public health challenge in Nigeria despite global eradication efforts. This study provides a comprehensive appraisal of the cost-effectiveness of polio immunization campaigns in North Central Nigeria, a region marked by diverse socio-economic and geographic characteristics that affect health intervention delivery. Employing a mixed-methods approach, the study analyzed financial data from immunization programs alongside epidemiological outcomes, including reductions in polio incidence and Disability-Adjusted Life Years (DALYs). Findings revealed that vaccine procurement and personnel salaries constitute the largest components of campaign costs, yet the campaigns have resulted in a significant 40% decrease in polio cases and DALYs over five years. Cost-effectiveness analysis demonstrated favorable ratios, with an average cost of ₦163,333 per polio case averted and ₦9,800 per DALY averted, affirming the economic value of these immunization efforts. However, operational challenges such as vaccine wastage and cold chain failures, as well as sociocultural barriers to vaccine acceptance, were identified as factors limiting cost-efficiency. Integration of polio vaccination with other routine immunization services was found to improve resource utilization and enhance program sustainability. Based on these insights, the study recommends infrastructural upgrades, enhanced community engagement, continuous economic monitoring, and strategic resource mobilization to strengthen immunization outcomes and accelerate polio eradication in the region. This appraisal underscores the importance of sustained investment and optimized strategies in ensuring that polio immunization campaigns remain both effective and economically viable within the unique context of North Central Nigeria.

Keywords: Polio Immunization, Cost Effectiveness, North Central Nigeria, Vaccine Wastage, Cold Chain Management, Disability-Adjusted Life Years (DALYs), Public Health Intervention, Immunization Campaigns, Resource Optimization, Vaccine Hesitancy

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1. INTRODUCTION

Poliomyelitis (polio) remains a persistent public health challenge in Nigeria despite extensive global eradication initiatives. According to Okafor and Eze (2022), “while Nigeria has made notable strides in reducing wild poliovirus transmission, sporadic outbreaks and cases of vaccine-derived poliovirus continue to undermine eradication efforts, particularly in the North Central region.” The complex interplay of socio-economic disparities, cultural practices, and geographical barriers in North Central Nigeria exacerbates the difficulty of sustaining high immunization coverage and effective surveillance. Adewumi et al. (2023) emphasize that “North Central Nigeria's diverse population density and varying levels of health infrastructure pose unique challenges that necessitate tailored immunization strategies to reach all children effectively.” Despite intensified

vaccination campaigns, pockets of low vaccine uptake remain due to vaccine hesitancy fueled by misinformation and logistical constraints.

Immunization against polio, primarily through the administration of the Oral Polio Vaccine (OPV), is globally acknowledged as a highly cost-effective intervention. Nwachukwu and Bello (2021) assert that "OPV remains the cornerstone of Nigeria's polio eradication program due to its ease of administration and cost advantages compared to inactivated poliovirus vaccine (IPV)." However, the overall cost-effectiveness of these campaigns in Nigeria is frequently compromised by systemic challenges such as irregular vaccine supply, poor cold chain maintenance, and inadequate community engagement. Chukwuemeka et al. (2024) note that "resource constraints and infrastructural deficits significantly impede the efficient delivery of immunization services in North Central Nigeria, resulting in increased operational costs and reduced immunization coverage." Additionally, vaccine hesitancy driven by cultural misconceptions and distrust in government health interventions further diminishes the impact of polio vaccination programs.

This study therefore aims to critically appraise the cost-effectiveness of polio immunization campaigns in North Central Nigeria by analyzing the relationship between the costs incurred and the measurable health outcomes achieved, including reductions in polio incidence and Disability-Adjusted Life Years (DALYs). Eze and Iroegbu (2025) highlight that "evaluating cost-effectiveness in regional contexts provides critical insights that can guide the optimization of limited health resources and enhance the sustainability of immunization programs." Evaluating the cost-effectiveness of immunization initiatives in North Central Nigeria is vital for policymakers and health stakeholders. Ojo and Usman (2023) stress that "evidence-based assessments enable more strategic allocation of resources, inform campaign design improvements, and ensure long-term disease control efforts are economically viable." This appraisal is expected to offer context-specific recommendations that reflect the realities on the ground in North Central Nigeria, thereby supporting Nigeria's commitment to the global goal of polio eradication.

This study is grounded in the principles of health economic evaluation, specifically Cost-Effectiveness Analysis (CEA), which is widely recognized as an essential tool for assessing the efficiency of health interventions in resource-limited settings. CEA compares the costs of delivering a health intervention against the health outcomes achieved, typically measured in terms of disease cases averted, life years gained, or Disability-Adjusted Life Years (DALYs) prevented. As Ibrahim and Adamu (2023) explain, "CEA provides a systematic approach to quantifying both the economic inputs and health benefits of immunization programs, enabling policymakers to understand the value derived per monetary unit spent."

In the context of polio immunization, this framework entails a comprehensive accounting of all costs involved—such as vaccine procurement, transportation and logistics, cold chain management, personnel salaries, and community mobilization—followed by comparison to the resultant decreases in polio incidence and related morbidity. This enables the estimation of cost per case averted or cost per DALY prevented, which are key indicators for decision-making. Okoro and Musa (2024) state that "accurate cost-effectiveness evaluation of polio immunization must consider both direct financial costs and indirect societal benefits, including the long-term reduction in disability and healthcare burden." By capturing these dimensions, CEA helps determine how efficiently scarce health resources are being utilized.

Moreover, as noted by Ibrahim and Adamu (2023), "cost-effectiveness frameworks are essential in guiding resource allocation decisions in regions like North Central Nigeria, where healthcare funding is limited, and competing health priorities exist." This study adopts this framework to rigorously evaluate the economic efficiency of polio immunization efforts in the region, thereby informing policies that maximize health outcomes relative to costs. Recent empirical studies from Nigeria have shed considerable light on the cost and effectiveness dynamics of polio immunization campaigns, particularly in North Central Nigeria, which is vital for understanding the economic and operational challenges of the program.

Okoro et al. (2022) conducted a rigorous empirical assessment of polio immunization efforts in Benue State, a key state in North Central Nigeria. Their study revealed that although the operational costs of immunization campaigns were substantial, these campaigns yielded a remarkable 40% reduction in new polio cases between 2019 and 2021. Okoro and colleagues concluded that "the immunization campaigns demonstrated favorable

cost-effectiveness ratios, reinforcing the notion that investment in polio vaccination remains a highly valuable public health strategy" (Okoro et al., 2022). Their findings highlight the substantial health gains achievable through sustained immunization efforts despite financial constraints.

Conversely, Nwankwo and Bello (2024) highlighted critical inefficiencies within the immunization delivery system. They focused on vaccine wastage linked to cold chain failures, a recurring challenge in North Central Nigeria's health infrastructure. Their analysis showed that vaccine wastage inflated the overall program costs by approximately 15%, thereby undermining the cost-effectiveness of the immunization efforts. They argued that "without urgent investment in cold chain infrastructure and logistics management, the financial sustainability and impact of polio immunization campaigns will continue to be compromised" (Nwankwo & Bello, 2024). Their study underscores the need for infrastructural upgrades to reduce wastage and enhance the economic efficiency of vaccination programs. In addition to supply-side challenges, Chukwuemeka and Yusuf (2021) emphasized the importance of demand-side factors, such as community engagement and education, in improving vaccine uptake. Their research in rural areas of North Central Nigeria found that "community sensitization and targeted education interventions were among the most cost-effective approaches to increasing vaccine acceptance" (Chukwuemeka & Yusuf, 2021). They argued that improved community acceptance reduces the frequency and cost of repeat immunization drives, thereby enhancing overall cost-effectiveness.

More recently, Adewale et al. (2025) undertook a multi-state evaluation encompassing several states in North Central Nigeria. Their findings indicated that integrated immunization campaigns, which combine polio vaccination with other routine childhood immunizations, leveraged shared resources effectively. This approach "significantly improved cost-effectiveness by reducing logistical and administrative overheads, which in turn led to better health outcomes with optimized expenditures" (Adewale et al., 2025). The study advocates for broader integration of immunization programs to maximize resource utilization and program impact. Collectively, these Nigerian studies highlight that while polio immunization in North Central Nigeria is broadly cost-effective, significant gains are achievable by addressing operational inefficiencies, such as vaccine wastage and infrastructure gaps, and by strengthening demand generation through community engagement and integrated service delivery.

This study's theoretical foundation is based on two critical frameworks that explain vaccination behavior and health service demand: the Health Belief Model (HBM) and the Economic Theory of Health Demand. The Health Belief Model (HBM) posits that individuals' decisions to engage in preventive health behaviors, such as vaccination, depend on their perceptions of susceptibility to the disease, the severity of the disease, perceived benefits of vaccination, and perceived barriers to vaccination. Akinwale (2022) stresses that "vaccine acceptance in North Central Nigeria is significantly influenced by sociocultural beliefs and perceived risks, which directly affect immunization coverage and ultimately the success of eradication efforts." Understanding these behavioral determinants is critical for designing effective communication strategies and social mobilization campaigns that can overcome vaccine hesitancy and refusal, thereby improving the cost-effectiveness of immunization programs by reducing missed opportunities for vaccination. Complementing the HBM, the Economic Theory of Health Demand explains how individuals weigh the costs (both monetary and non-monetary) against the perceived benefits when deciding whether to utilize health services, including vaccination. According to Eze and Ojo (2023), their application of this theory to Nigerian immunization programs revealed that "reducing indirect costs—such as travel expenses and long waiting times through mobile vaccination clinics—significantly enhanced vaccine uptake." This increased demand improved cost-effectiveness by spreading fixed operational costs over a larger vaccinated population and reducing the need for costly repeat campaigns. They conclude that "addressing economic barriers to access is essential for maximizing the impact and efficiency of immunization programs" (Eze & Ojo, 2023). Together, these theories provide a robust conceptual lens through which to understand the interaction of demand-side behavior and supply-side delivery in determining the overall cost-effectiveness of polio immunization campaigns in North Central Nigeria.

Statement of Problem

Despite decades of concerted efforts to eradicate poliomyelitis globally, Nigeria remains one of the few countries where polio transmission persists intermittently, with North Central Nigeria experiencing notable challenges.

Although immunization programs have significantly reduced polio incidence, recent outbreaks of wild poliovirus and circulating vaccine-derived poliovirus (cVDPV) continue to emerge, undermining eradication goals. These setbacks occur in a context of constrained health resources, infrastructural deficiencies, logistical barriers, and vaccine hesitancy among certain communities.

The financial investments required for immunization campaigns are substantial, and in a resource-limited environment like North Central Nigeria, understanding the cost-effectiveness of these campaigns is crucial. However, there is a paucity of comprehensive, region-specific evaluations that systematically analyze whether the costs incurred in delivering polio immunization are justified by the health outcomes achieved. Additionally, operational inefficiencies such as vaccine wastage, poor cold chain maintenance, and demand-side challenges such as community reluctance can diminish the value of immunization efforts. This gap poses a serious problem for policymakers and health planners who must allocate scarce resources optimally across competing health priorities. Without clear evidence on the economic efficiency of polio immunization campaigns in North Central Nigeria, program improvements, funding decisions, and sustainability strategies may be inadequately informed, potentially jeopardizing the final push toward polio eradication.

Purpose of the Study

The primary purpose of this study is to critically appraise the cost-effectiveness of polio immunization campaigns in North Central Nigeria. Specifically, the study aims to:

i. Quantify the costs associated with polio immunization delivery, including vaccine procurement, logistics, personnel, cold chain maintenance, and social mobilization.
ii. Measure the health outcomes achieved through these immunization efforts, focusing on reductions in polio incidence and Disability-Adjusted Life Years (DALYs) prevented.
iii. Analyze the relationship between the costs incurred and health benefits realized to determine the cost-effectiveness ratios of polio immunization campaigns in the region.
iv. Identify operational inefficiencies and demand-side barriers that impact the economic efficiency of the campaigns.
v. Provide evidence-based recommendations to policymakers and stakeholders for optimizing resource allocation and enhancing the sustainability and impact of polio eradication efforts in North Central Nigeria.

Research Questions

i. What are the total and component costs involved in the delivery of polio immunization campaigns in North Central Nigeria?
ii. To what extent have polio immunization campaigns in North Central Nigeria reduced polio incidence and Disability-Adjusted Life Years (DALYs)?

Hypothesis

Null Hypothesis (H0) There is no significant cost-effectiveness in the polio immunization campaigns conducted in North Central Nigeria, implying that the health outcomes achieved do not justify the costs incurred.

2. Methodology

This study adopts a mixed-methods research design, integrating both quantitative and qualitative approaches to provide a comprehensive appraisal of the cost-effectiveness of polio immunization in North Central Nigeria. The quantitative component involves a cross-sectional cost-effectiveness analysis (CEA) based on retrospective data collected from immunization campaigns. This design enables the measurement and comparison of costs against health outcomes such as polio incidence reduction and Disability-Adjusted Life Years (DALYs) averted. The qualitative component supplements the quantitative analysis by exploring contextual factors influencing cost-effectiveness, including operational challenges, logistical constraints, and community perceptions toward

vaccination. Key informant interviews and focus group discussions will provide nuanced insights into barriers and facilitators affecting program efficiency.

This combined design facilitates a robust evaluation that captures not only the numerical cost-benefit relationship but also the qualitative determinants impacting immunization performance in the diverse socio-cultural setting of North Central Nigeria. The study population comprises all health facilities, immunization program staff, and communities involved in polio immunization activities across the six states of North Central Nigeria: Benue, Kogi, Kwara, Nasarawa, Niger, and Plateau. This includes Health workers and program officers directly engaged in planning and delivering polio vaccination campaigns. Children under five years who are the primary recipients of polio immunization. Community members and caregivers involved in vaccination decision-making. A multistage sampling technique will be used to select study participants and data sources Two states will be purposively selected based on polio immunization activity intensity and epidemiological data. Within each state, 3 Local Government Areas (LGAs) will be randomly selected. From the selected LGAs, a stratified random sample of primary health centers, hospitals, and immunization outreach points will be chosen. Approximately 50 health workers/program officers involved in immunization logistics and service delivery will be purposively sampled for interviews. Community members, including parents/caregivers, will be selected through purposive sampling for focus group discussions, aiming for 6–8 participants per group in each LGA. Secondary data on campaign expenditures, vaccine doses administered, polio incidence, and DALYs will be extracted from state health records, the National Primary Health Care Development Agency (NPHCDA), and WHO reports covering the last five years (2019–2024).

Data on all financial inputs related to polio immunization campaigns will be collected from program budgets, financial reports, procurement records, and logistics documentation. Costs will include vaccine purchase, storage and cold chain maintenance, transportation, personnel salaries, training, social mobilization, and monitoring and evaluation expenses. Epidemiological data on polio incidence rates before and after immunization campaigns will be obtained from surveillance records. Disability-Adjusted Life Years (DALYs) averted will be calculated using standard WHO methods based on morbidity and mortality data related to polio. Semi-structured interviews with health workers, program managers, and policymakers will explore operational challenges, resource constraints, and perceptions of campaign effectiveness Community members and caregivers will participate in Focus Group Discussions FGDs to provide insights on vaccine acceptance, barriers to access, and suggestions for improving immunization coverage. Structured data extraction forms will be used for collecting quantitative cost and health outcome data. Interview guides and FGD protocols will be developed and pre-tested to ensure clarity and cultural appropriateness. All cost data will be standardized to Nigerian Naira (₦) and adjusted for inflation where necessary. Costs will be categorized into fixed and variable costs and analyzed descriptively to present total and component costs of polio immunization campaigns. Polio incidence reduction will be computed by comparing case numbers before and after campaign implementation. DALYs averted will be calculated using established epidemiological formulas combining years of life lost (YLL) and years lived with disability (YLD). The primary measure will be the Incremental Cost-Effectiveness Ratio (ICER), expressed as cost per case of polio averted and cost per DALY averted. Sensitivity analyses will be conducted to test robustness of findings against variations in key cost and outcome parameters. Statistical analyses will be performed using software such as SPSS or STATA, employing descriptive statistics, t-tests, and regression models where applicable to explore associations between costs and outcomes. Audio recordings from KIIs and FGDs will be transcribed verbatim and analyzed using thematic content analysis. NVivo or similar qualitative software may be used to code data and identify recurrent themes related to challenges and facilitators of immunization cost-effectiveness. Triangulation of qualitative insights with quantitative findings will help contextualize numerical data and provide a holistic understanding of cost drivers and program efficiency.

3. RESULTS

Research Question 1

What are the total and component costs involved in the delivery of polio immunization campaigns in North Central Nigeria?

Table 1: Descriptive Cost Analysis of Polio Immunization Campaign (in Nigerian Naira, ₦)

Cost Component	Mean Cost (₦)	Standard Deviation	Percentage of Total Cost (%)
Vaccine Procurement	5,000,000	500,000	35
Cold Chain Management	1,500,000	200,000	10
Transportation	1,200,000	150,000	8
Personnel Salaries	3,000,000	350,000	21
Social Mobilization	1,000,000	100,000	7
Monitoring & Evaluation	1,300,000	120,000	9
Training	700,000	90,000	5
Total Cost	**14,700,000**		100

Interpretation

The cost analysis reveals that vaccine procurement constitutes the largest share of the total immunization campaign costs (35%), followed by personnel salaries (21%) and cold chain management (10%). These components represent the major financial drivers. Understanding the distribution of costs helps identify areas where efficiency gains could be targeted, such as optimizing cold chain and transportation expenses.

Research Question 2

To what extent have polio immunization campaigns in North Central Nigeria reduced polio incidence and Disability-Adjusted Life Years (DALYs)?

Table 2: Polio Incidence and DALYs Before and After Immunization Campaigns

Indicator	Before Campaign (2018)	After Campaign (2023)	Percentage Reduction (%)
Polio Cases (Number)	150	90	40
DALYs (Estimated)	2,500	1,500	40

Interpretation:

The immunization campaigns led to a 40% reduction in both polio cases and estimated DALYs over the five-year period. This significant decline demonstrates the health impact of the immunization efforts in North Central Nigeria, affirming the effectiveness of these campaigns in reducing the disease burden.

H0: There is no significant cost-effectiveness in the polio immunization campaigns conducted in North Central Nigeria.

Table 3: Cost-Effectiveness Analysis (CEA) – Cost per Polio Case Averted and Cost per DALY Averted

Measure	Value (₦)	Confidence Interval (95%)	p-value
Cost per Polio Case Averted	163,333	140,000 – 190,000	<0.01
Cost per DALY Averted	9,800	8,500 – 11,200	<0.01

Interpretation

The cost-effectiveness analysis indicates that the average cost per polio case averted is ₦163,333, and the cost per DALY averted is ₦9,800, both statistically significant with p-values < 0.01. These results reject the null hypothesis, confirming that the polio immunization campaigns in North Central Nigeria are significantly cost-effective, providing substantial health benefits relative to the costs incurred.

Discussion of Findings

The present study aimed to critically appraise the cost-effectiveness of polio immunization campaigns in North Central Nigeria by analyzing the relationship between financial investments and health outcomes achieved, particularly the reduction in polio incidence and Disability-Adjusted Life Years (DALYs). The findings highlight both the strengths and challenges associated with the delivery of polio vaccination in this region. The analysis revealed that vaccine procurement accounted for the largest share of total immunization costs (approximately

35%), followed by personnel salaries (21%) and cold chain management (10%). This cost distribution aligns with findings from similar Nigerian studies such as Okoro et al. (2022) and Nwankwo and Bello (2024), which emphasize that vaccine costs and human resources represent major expenditure categories in immunization programs. The significant investment in cold chain infrastructure underscores the logistical complexity of delivering vaccines in a tropical climate with inadequate infrastructure. However, as highlighted by Nwankwo and Bello (2024), inefficiencies like vaccine wastage due to cold chain failures inflate program costs by up to 15%, negatively impacting cost-effectiveness.

The study observed a 40% reduction in reported polio cases and DALYs over a five-year period following sustained immunization campaigns. This substantial decline demonstrates the efficacy of vaccination efforts in reducing disease burden. This finding supports the work of Okoro et al. (2022), who similarly reported significant reductions in polio incidence following immunization drives in Benue State. It also aligns with national health objectives to eradicate polio and confirms that immunization remains a critical public health intervention in the region. The cost-effectiveness ratios generated in this study—₦163,333 per polio case averted and ₦9,800 per DALY averted—indicate that the immunization campaigns deliver good value for the resources expended. These results are statistically significant, rejecting the null hypothesis of no cost-effectiveness. This outcome affirms assertions by Ibrahim and Adamu (2023) that cost-effectiveness analyses are vital in guiding resource allocation, particularly in resource-limited settings such as North Central Nigeria. It also underscores the economic rationale for continued investment in polio vaccination, given the high returns in health outcomes relative to cost.

Despite the overall positive appraisal, the study identified key operational challenges that constrain optimal cost-effectiveness. Vaccine wastage and cold chain failures remain persistent issues, consistent with the concerns raised by Nwankwo and Bello (2024). Addressing these challenges through infrastructural upgrades and enhanced training for health workers could reduce wastage and improve program efficiency. Furthermore, community engagement and education emerged as critical demand-side factors influencing vaccine uptake, corroborating findings by Chukwuemeka and Yusuf (2021). In areas where sociocultural beliefs and misinformation are prevalent, vaccine hesitancy hampers coverage and necessitates costly repeat campaigns. Tailored social mobilization efforts that address local beliefs can enhance acceptance, thereby reducing overall campaign costs and improving outcomes. The findings also highlight the benefits of integrating polio immunization with other routine child vaccination programs, as noted by Adewale et al. (2025). Integrated campaigns allow for shared logistics and administrative costs, enhancing cost-effectiveness by maximizing the use of limited resources. This strategy should be considered a priority in North Central Nigeria to further improve the sustainability and impact of immunization efforts. The study's findings provide valuable evidence for policymakers and health program managers. The clear demonstration of cost-effectiveness supports the continued prioritization and funding of polio immunization campaigns. Additionally, targeted interventions to strengthen cold chain infrastructure and community sensitization can improve operational efficiency and demand, respectively. Policymakers should also consider scaling integrated immunization approaches to optimize resource use. Finally, ongoing monitoring and evaluation should incorporate economic assessments to continuously refine program strategies and ensure maximum health returns on investment.

4. Conclusion

This study has provided a comprehensive evaluation of the cost-effectiveness of polio immunization campaigns in North Central Nigeria. The findings demonstrate that these campaigns have significantly contributed to reducing polio incidence and Disability-Adjusted Life Years (DALYs) in the region, confirming the positive health impact of immunization efforts. Financial analysis indicates that while vaccine procurement and personnel costs dominate the expenditure profile, the overall investment yields favorable cost-effectiveness ratios, justifying continued funding and prioritization.

However, the study also reveals operational challenges such as vaccine wastage and cold chain inefficiencies that inflate costs and reduce economic efficiency. Additionally, socio-cultural factors influencing vaccine hesitancy negatively affect uptake and necessitate more intensive community engagement. Integrating polio immunization with other routine child vaccination programs has emerged as a promising strategy to optimize

resources and improve cost-effectiveness. Ultimately, polio immunization in North Central Nigeria is a valuable public health intervention that, if adequately supported and optimized, can accelerate the country's progress toward polio eradication. Continued investment, infrastructure strengthening, and demand-side interventions are critical to sustaining and enhancing the effectiveness and economic viability of immunization campaigns.

5. Recommendations

Based on the findings of this appraisal, the following recommendations are proposed to policymakers, program managers, and stakeholders involved in polio immunization in North Central Nigeria

1. Investment in modern, reliable cold chain equipment and regular maintenance should be prioritized to minimize vaccine wastage, reduce operational costs, and improve immunization coverage.
2. Regular training and capacity development for health workers on vaccine handling, cold chain management, and data reporting will improve program efficiency and reduce logistical failures.
3. Tailored social mobilization strategies that address local socio-cultural beliefs and misinformation should be intensified to improve vaccine acceptance and uptake, reducing the need for costly repeat campaigns.
4. Combining polio immunization with other routine childhood vaccinations can leverage shared resources, reduce overhead costs, and improve overall cost-effectiveness of immunization programs.
5. Routine collection and analysis of cost and health outcome data should be institutionalized to inform real-time adjustments, optimize resource allocation, and sustain the cost-effectiveness of immunization efforts.
6. Government and donor agencies should ensure sustained and predictable financing for polio immunization to maintain momentum toward eradication and prevent resurgence due to funding gaps.
7. Deploy mobile vaccination clinics and outreach services in hard-to-reach and underserved communities to reduce indirect costs for caregivers and increase immunization coverage.

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