Estimating the cost of identifying and vaccinating zero-dose children in urban and rural geographies in Pakistan

Study report

THINK WELL

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ACRONYMS

Acronym	Definition
BCG	Bacillus Calmette-Guérin
COW	Clinics on Wheels
DHO	District Health Office
EMR	Electronic Medical Records
EPI	Expanded Program on Immunization
HMIS	Hospital Management Information System
HSA	Health Services Academy
IMF	International Monetary Fund
IRB	Institutional Review Board
IRMNCH&NP	Integrated Reproductive, Maternal, Newborn and Child Health and Nutrition Program
KPK	Khyber Pakhtunkhwa
LHW	Lady Health Workers
LMIC	Low- and Middle-Income Countries
MR	Measles-Rubella
OPV	Oral Polio Vaccine
PEI	Polio Eradication Initiative
PHC	Primary Health Care
PKR	Pakistani Rupee
UNICEF	United Nations Children's Fund
USD	United States Dollar
VPD	Vaccine-Preventable Disease
WHO	World Health Organization
ZM	Zindagi Mehfooz

1. EXECUTIVE SUMMARY

Introduction

Pakistan faces persistent immunization challenges, with almost 400,000 zero-dose children reported in 2024 and ongoing polio endemicity. To tackle the high burden of zero-dose children, the government has introduced a range of targeted initiatives, yet their comparative cost and impact have remained unclear. PHC Global and ThinkWell assessed the cost, output and operational realities of zero-dose initiatives and routine delivery across Punjab and Sindh to fill this critical evidence gap. As Pakistan prepares to shoulder greater financial responsibility for its immunization program amid reduced donor support, robust cost evidence is vital for prioritizing strategies to maximize impact from the resources invested.

Methods

This study employed a bottom-up and ingredients-based approach to estimate the financial and economic costs for three zero-dose interventions: polio house-to-house campaigns, Clinics on Wheels, and integrated outreach activities. The latter refers to enhanced outreach rather than integrated outreach across different health areas. To provide a comparison with non-zero dose focused delivery strategies, routine delivery through fixed sites and regular outreach was also examined. Costs were captured retrospectively from 56 sites across provincial, district, and implementation levels in seven districts. Quantitative data collection was complemented by a thematic qualitative assessment at all sites to understand the enabling factors and barriers in identifying and vaccinating zero-dose children.

Findings

The average incremental economic cost of leveraging polio house-to-house campaigns to identify zero-dose children was estimated between $9.24 and $17.21 per zero-dose child identified, reflecting only additional staff and volunteer time, as no additional financial costs were incurred. Incremental identification costs were markedly higher in rural areas ($26.60–$44.15) than urban areas ($5.06–$9.09), due to the greater number of zero-dose children identified in urban areas, where higher population density allows teams to reach households more efficiently.

The cost of reaching zero-dose children varied across strategies. The economic cost per zero-dose child reached ranged from $39.85 for regular (routine) outreach to $47.13 for integrated outreach, $54.36 for Clinics on Wheels, and $58.68 for fixed-site delivery. Financial cost drivers differed by strategy: transport and fuel for regular outreach, transport, fuel and per diems for integrated outreach, and contractual staff for Clinics on Wheels. However, across all strategies, opportunity costs made up the bulk of the economic cost per dose, largely reflecting the labor of existing staff.

Findings revealed critical supply- and demand-side barriers for reaching zero-dose children in Pakistan, and these challenges differ across settings and districts. Supply-side barriers include such as human resources, service quality, and infrastructure and resource gaps. Demand-side barriers include knowledge and awareness, poverty, cultural practices, migration and mobility challenges, as well as service experience.

We found that the effectiveness and cost-efficiency of each delivery strategy depended on its ability to address the specific barriers in reaching zero-dose children. Across most rural settings, integrated outreach activities were more cost-efficient per zero-dose child, as they helped bridge resource gaps and achieved higher zero-dose coverage than routine outreach. Conversely, in urban districts, regular outreach was shown to be the most cost efficient, underscoring the relatively limited impact of integrated outreach activities in areas where issues such as vaccine hesitancy posed a greater barrier than supply-side constraints, and the continuity of routine outreach services helps to build community's trust in the health system. Informal settlements represent a context where Clinics on Wheels can be particularly impactful in

reaching zero-dose children, and financial incentives in poverty-affected contexts helped boost the zero-dose reach of fixed-site delivery above average levels.

Key takeaways

- To be most effective at reaching zero-dose children, the immunization strategies must match the specific zero-dose barrier of the context where they are implemented.
- Integrated outreach activities should be strategically deployed only where routine service delivery is constrained, not as a blanket intensification across provinces.
- Clinics on Wheels should be leveraged as a highly targeted intervention, most effective in areas where zero-dose children are concentrated in informal settlements.
- Integrating zero-dose identification into polio house-to-house campaigns is relatively cost-efficient, as it requires no additional financial costs.
- Regular outreach has strong potential for reaching zero-dose children if adequately resourced with sufficient human resources, effective microplanning, and reliable financing for transportation and logistics.

2. INTRODUCTION

2.1 OVERVIEW

Pakistan continues to struggle with significant immunization gaps, marked by a large zero-dose population and continued polio endemicity. In Pakistan, the Expanded Program on Immunization (EPI) is the largest vertical program in the country, aiming to provide essential vaccines to children. Yet over one million children miss their routine vaccines in the country each year.[1] The country stands among the 10 countries where almost 60 percent of the world's zero-dose children reside, defined as those children who have not received even a single vaccine dose.[2] (See Box 1). Further, it is one of only two countries where polio is still endemic. In 2024, there were an estimated 396,899 zero-dose and 925,000 un- and under vaccinated children in the country.[3] Reaching these missed children is a key focus of both the World Health Organization (WHO) Immunization Agenda 2030 and Gavi's 5.0 and future 6.0 strategies.[4,5]

Box 1 – Zero-Dose Definitions in Pakistan

The country uses different program specific operational definitions for zero-dose children. The EPI aligns with the global Gavi definition of children who missed Penta 1 though it is unclear at by what age, while Polio Eradication Initiative (PEI) defines zero-dose as children who have not received any injectable vaccine. This distinction reflects the polio program's strategic use of a broader definition to cast a wider net in identifying unreached children who have missed any injectable vaccine (such as Bacillus Calmette-Guérin (BCG) vaccine) irrespective of age.

PHC Global and ThinkWell have assessed the costs, effectiveness, and operational factors affecting zero-dose initiatives across Pakistan, to fill a stark evidence gap on the economics of reaching zero dose children. To address the substantial zero-dose children burden, the government has implemented various zero-dose identification and coverage initiatives across different provinces and districts. These programs are designed to improve and sustain overall vaccination coverage by targeting at-risk and missed communities. However, the extent to which these strategies have been successful in relation to their cost and output was not known. To fill this evidence gap, PHC Global and ThinkWell carried out an analysis to estimate the financial and economic costs associated with these interventions, as well as routine delivery across Punjab and Sindh. The study incorporates a qualitative assessment to capture operational realities, bottlenecks, and enabling factors that influence intervention performance.

2.2 RATIONALE

As Pakistan assumes greater responsibility for financing its immunization program, reliable cost evidence is critical to ensure sustainability. To complement routine immunization services, the Government of Pakistan has launched multiple initiatives to identify and vaccinate zero-dose children across diverse settings, yet little is known about the resources required for these efforts. With donor funding on the decline, it is increasingly vital that decision-makers and program managers have robust evidence on the financial and operational realities of reaching the unreached. This evidence is essential for weighing the trade-offs of reaching the most missed and hardest-to-reach children, where costs are often higher, but equity gains are greatest. Such evidence will help policymakers and program managers allocate national resources strategically, plan scale-ups, and ensure sustainable immunization coverage for all children.

2.3 OBJECTIVES

This study was designed with the following specific objectives:

- To estimate the cost per zero-dose child identified and vaccinated through selected zero-dose interventions and routine delivery.
- To estimate the total and incremental economic cost of delivering selected zero-dose interventions and routine delivery in targeted geographies.
- To assess the programmatic and financial enablers and bottlenecks influencing the implementation of targeted and routine interventions.
- To develop actionable recommendations for policy- and decision-makers at both federal and provincial levels based on the findings from this study.

3. METHODS

3.1 SELECTED INTERVENTIONS

From the range of zero-dose interventions implemented across Pakistan, key initiatives for the study were identified through comprehensive stakeholder consultation. Interventions were scored based on the criteria below, and those with the highest scores were selected for analysis:

- **Targeting zero-dose children:** the intervention specifically targets zero-dose children, according to the definitions of zero-dose employed by the EPI and the PEI.
- **Effective:** the intervention was, or in the absence of data was perceived by consulted stakeholders as, effective at reaching zero-dose children.
- **Cost-efficient:** the intervention was perceived as cost-efficient and therefore promising for scale-up.
- **Stakeholder interest:** stakeholders expressed a need to close the knowledge gap on the cost of the intervention.

A total of five interventions were selected for this analysis, including zero-dose specific interventions and routine strategies. Three key zero-dose targeted interventions were selected for costing analysis: 1. identification of zero-dose children through national-level polio house-to-house campaigns; 2. enhanced immunization-only outreach coined 'integrated outreach activities' planned at provincial level; 3. mobile vans with integrated primary care services (Clinics on Wheels) implemented across select districts in Punjab. To provide a comparison with non-zero dose focused delivery strategies, routine delivery through fixed sites and regular outreach was also examined. While polio house-to-house campaigns are designed to identify zero-dose children, all other selected strategies focus on service delivery. A description of each intervention included in the study is outlined below:

- **Polio house-to-house campaigns:** the largest community-based vaccination drives led by the PEI to deliver oral polio vaccines (OPV) on the doorstep across the country. Conducted several times a year over five- to seven-day stretches, these systematic door-to-door efforts mobilize vaccinators, community mobilizers, and supervisors to reach every child under five with OPV. Since 2018, polio campaigns have been strategically adapted to identify zero-dose children during home visits. Polio teams assess children's immunization status by reviewing vaccination cards and checking for a BCG mark; children missing injectable vaccines are recorded manually, and their data shared with EPI electronically. No

injectable vaccine is administered during the house visits. The campaigns are planned under the PEI department but heavily donor funded.

- **Integrated outreach activities:** an outreach campaign-style delivery strategy to deliver immunizations to underserved and low-performance areas across the country. Vaccination teams accompanied by a trained social mobilizer establish an outreach site in low-performing areas where routine immunization targets are not met. These campaigns were delivered through routine outreach sites along with supplementary strategically located sites, and typically lasted 12 days to one month. They were carried out two to three times a year with the support from Gavi and WHO, planned under EPI provincial directives.

- **Clinics on Wheels***:* a Government of Punjab initiative, using mobile primary health care vans to serve urban communities with limited access to fixed facilities across Punjab. Each of the 202 fully equipped vans delivers a broad package of essential services, including immunizations, antenatal care, nutrition support, and maternal and child health interventions. The initiative is coordinated by the Integrated Reproductive, Maternal, Newborn and Child Health and Nutrition Program (IRMNCH&NP), and services are delivered daily to different communities, rotating locations on a monthly schedule. The intervention is predominantly government funded, with some in-kind and financial support from donors and partners.

- **Fixed site delivery:** Routine vaccination services delivered at designated primary health facilities that operate on a regular schedule across the country. This usually takes place on a daily basis and is financed by the government.

- **Regular outreach:** Health workers provide vaccinations on a routine schedule at outreach sites in nearby communities named kit stations, targeting populations with limited access to health facilities. This is government funded and typically conducted on a daily basis across the country

3.2 STUDY DESIGN

A mixed-method design was employed to examine the financial and operational costs, as well as programmatic insights for three zero-dose interventions and routine immunization strategies in Pakistan. This study collected identification and delivery-related costs retrospectively at the point of implementation (e.g. facility, mobile clinic or in the community), district and provincial levels. In addition to the costing study, a qualitative analysis assessed the operational realities and programmatic challenges of identifying and reaching zero-dose children. The time period for data collection focused on the most recent campaign and a recent month of routine activity. For polio house-to-house campaigns, the study also examined a campaign implemented one year prior (Table 1).

Costs were estimated using a bottom-up (ingredients-based) approach, considering both financial and economic costs from a payer perspective. All key program activities such as service delivery, social mobilization, training, recordkeeping, and program management were costed at each administrative level. This was done by measuring the quantity of inputs (or resources) required for each activity and multiplying these by their respective unit prices. A full list of program activities and resources included in the costing is provided in Annex 1. Strategies were categorized based on whether they focused on identifying zero-dose children or vaccinating them (Table 1).

Table 1. Time periods for each intervention

Intervention	Time period costed	Type of strategy
Polio house-to house campaigns	27 November - 3 December 2023 28 October - 3 November 2024 *(Both Punjab and Sindh)*	Identifying and reporting zero-dose children
Fixed site	September 2024 *(Punjab)* October 2024 *(Sindh)*	Vaccinating zero-dose children
Regular (Routine) outreach	September 2024 *(Punjab)* October 2024 *(Sindh)*	Vaccinating zero-dose children
Integrated outreach activities	April 2024 *(Punjab)* 9-21 October 2023 *(Sindh)*	Vaccinating zero-dose children
Clinics on Wheels	September 2024 *(Punjab only)*	Vaccinating zero-dose children

Institutional Review Board (IRB) of the Health Services Academy (HSA), Islamabad provided ethical approval for the study in August 2024.

3.3 SAMPLE SELECTION

Multi-level purposive sampling was employed across provincial, district, and facility levels in Punjab and Sindh provinces to capture perspectives from service delivery and administrative levels. Districts and sites were selected in close consultation with EPI based on predetermined criteria including Gavi priority status, population size, immunization coverage rates, and zero-dose child prevalence. Geographic representation across urban and rural settings was prioritized to capture variation in delivery challenges and cost structures characterizing Pakistan's diverse operational landscape. We used the Pakistan Bureau of Statistics' administrative definition of 'urban', where urban areas are those noted as municipal corporations, municipal committees, town committees, or cantonments.

The final selection included districts Lahore, Faisalabad, Bahawalnagar, DG Khan in Punjab province, and Karachi West, Ghotki, and Qambar Shahdadkot in Sindh province. The sample included 42 primary health facilities: 24 in Punjab (six per district) and 18 in Sindh (six per district). Additionally, two mobile clinics under the Clinics on Wheels program were selected from Lahore and Faisalabad, in Punjab province. The facilities and clinics covered 26 union councils, serving as the lowest administrative level in Pakistan. The sample also included seven district offices, one for each sampled district. At the provincial level, the sample comprised one WHO office, one PEI office, two EPI offices (one in Punjab and one in Sindh), and one IRMNCH&NP office (Punjab). At the provincial level, WHO Sindh, PEI Sindh, and UNICEF Sindh and Punjab did not provide the requested data, resulting in a final sample of 56 sites across Punjab and Sindh provinces (see Table 2).

Table 2. Final sample overview

Level	Site Type	Punjab	Sindh	Total
Provincial level	WHO Office	1	–	1
	PEI Office	1	–	1
	EPI Office	1	1	2
	IRMNCH&NP Office	1	–	1
District level	District health offices	4 *(2 rural, 2 urban)*	3 *(2 rural, 1 urban)*	7
Implementation/ Union Council level	Primary health facilities	24	18	42
	Clinics on wheels	2	–	2
	Total Sites			**56**

3.4 DATA COLLECTION

Qualitative and quantitative data were collected between December 2024 and May 2025 through structured, in-person interviews and review of administrative immunization records. All interviews were conducted through face-to-face engagement by trained field teams using a standardized Excel-based questionnaire designed for direct data entry. At implementation level, a total of 42 interviews were conducted with healthcare personnel including vaccinators, lady health workers, medical officers, and facility in-charges. An additional 14 interviews were conducted at administrative levels and with partners, including with district health officers, district logisticians, EPI managers, WHO technical staff, PEI coordinators, and IRMNCH&NP program officers, who also provide their perspectives on intervention implementation. The questionnaires captured resource use, operational experiences, and implementation enablers and challenges across the different delivery modalities. Data was captured about site characteristics, microplanning, service delivery, staffing, community mobilization, logistics, cold chain, reporting, training, supervision, financial management, coverage.

Site-level data were supplemented with information from multiple electronic information systems. Data on the number of zero-dose children identified were obtained from the Polio Synergy Database in Punjab

and from the Google Sheet tracking system in Sindh. The number of zero-dose children reached was accessed from the Electronic Medical Records (EMR) database in Punjab, and the Zindagi Mehfooz database in Sindh. When immunization records were unavailable at sites, vaccination coverage data were obtained from electronic information systems. Costs of equipment, salaries, and vehicles were obtained from publicly available sources and local supplier websites. Useful life assumptions were obtained from existing guidance on immunization costing.[6] All data underwent a structured process of cleaning and validation to ensure consistency, reliability, and readiness for analysis.

3.5 DATA ANALYSIS

Quantitative analysis

Site-level and administrative costs were categorized, adjusted for depreciation and inflation, and converted to 2024 USD, before estimating the volume-weighted average cost per dose and per zero-dose child. Costs were classified as either financial or opportunity costs and disaggregated by delivery strategy, resource type, and program activity (See Annex 1). The study accounted for both the direct financial outlays of implementing the delivery strategies (e.g., per diems and fuel costs), as well as the estimated value of using existing resources in the health system, such as staff, cold chain equipment, and vehicles. Capital items were depreciated on a straight-line basis using replacement prices and useful life years, with economic costs discounted at 3%. All costs are reported in 2024 USD, using an average exchange rate of 1 USD = 277.90275 Pakistani Rupee (PKR).[7] For the last integrated outreach activity in Sindh which took place in 2023, financial costs were then adjusted for inflation using the IMF's inflation rate for PKR and then converted into USD.[8] Unit costs were calculated using a volume-weighted average approach. For example, the volume-weighted cost per dose at vaccination sites was calculated by dividing the total cost incurred at the sites by the total number vaccine doses administered at those sites, using the formula:

$$unit\_cost_{vw} = \frac{\sum_{i=1}^{n} C_i}{\sum_{i=1}^{n} Q_i}$$

where Ci represents the total cost of vaccine delivery at location i, Qi is the total quantity of doses delivered at location i, and n is the sample size for that level. Since coverage data in Pakistan are recorded at the Union Council level, our analysis was conducted at this level, corresponding typically to two facilities per Union Council.

Applying the 18-week zero-dose definition, we estimated full costs for immunization-specific strategies and incremental costs for integrated strategies. To estimate the cost per zero-dose child identified for polio house-to-house campaigns, only implementation-level costs were considered and divided by the number of children aged 18 weeks or older who had not received any injectable vaccine, as reported in electronic registries. To estimate the cost per zero-dose child reached for the other interventions, implementation-level costs were divided by the number of children aged 18 weeks or older vaccinated with the first dose of the Penta vaccine, as reported in electronic registries. The 18-week definition for a zero-dose child was used for all strategies, aligning with recommendations from the Zero Dose Learning Hub.[9] For immunization-specific strategies—i.e. fixed site, regular outreach, and integrated outreach—the full cost of the intervention was estimated. For integrated strategies, including Clinics on Wheels and polio house-to-house campaigns, the incremental costs were calculated. For Clinics on Wheels, we defined incremental as the proportion of costs attributable to immunization, whereas for polio house-to-house campaigns, these were the additional costs of zero-dose identification and reporting. Union Councils that did not reach any zero-dose children under a given strategy were excluded from the aggregate cost calculations for that strategy.

Daily averages were calculated by dividing the total monthly or campaign doses, or the number of zero-dose children, by the number of days the intervention was implemented.

Qualitative analysis

Qualitative data collected across the whole sample were analyzed using a thematic analysis. Audio-recorded interviews were transcribed verbatim and translated from local languages into English. Transcripts were systematically organized and coded using an Excel-based analytical framework and developed themes by identifying patterns of the codes within and across interview transcripts. The coding methodology employed both deductive and inductive approaches. The deductive approach employed predefined themes identified in initial literature review, while the inductive approach allowed for identification of emergent sub-themes and themes from the participants responses. A full list of themes can be found in Annex 2.

Limitations

A few limitations of the study should be noted. First, data for integrated outreach activities in Sindh was collected about 1.5 years after implementation, which may have introduced recall bias. Second, estimates of zero-dose children relied on the electronic reporting system, which may not have been fully comprehensive given connectivity challenges at some sites. Third, though we asked respondents about the most recent month or campaign to minimize recall issues, this approach may not fully capture potential seasonal variations. Fourth, excluding Union Councils that did not reach any zero-dose children under a given strategy may have led to downward bias in the aggregate cost estimates. Finally, the barriers and drivers reflect service provider perspectives and therefore do not fully capture caregivers' own experiences or priorities.

4. QUALITATIVE FINDINGS

4.1 INTERVENTION COMPARISON

This section highlights key similarities and differences across implementation strategies. Overall, the delivery approaches varied widely in microplanning, community mobilization, service delivery, and reporting, with integrated outreach and polio campaigns generally benefiting from greater resources, while routine strategies often operated under significant constraints.

Microplanning

Microplanning for regular outreach employs mapping techniques, while integrated outreach activities utilized more targeted analyses to reach underserved areas. Across delivery strategies and in both Sindh and Punjab, target populations are estimated using population-based growth rates set at approximately 3% of the total catchment population. For regular outreach, the microplanning process uses mapping techniques, while integrated outreach activities followed a more comprehensive approach to target low-performing areas using data on zero-dose prevalence and area-specific immunization coverage trends. Facilities in Punjab develop annual microplans for regular outreach that are updated monthly, while facilities in Sindh created these quarterly. For integrated outreach activities, microplanning tends to be conducted one week before the campaign, though the timeline and specific activities varied by districts.

Data on identified zero-dose children from polio house-to-house campaigns feeds into EPI microplanning. The zero-dose identification data from polio house-to-house campaigns forms a critical component of EPI microplanning for regular outreach and integrated outreach activities. Vaccinators, via a phone application, receive a list of zero-dose children from campaigns in their catchment area, including name, address, and

contact details. Clinics on Wheels, managed by IRMNCH&NP department, reported limited direct access to data from the polio house-to-house campaigns. For Clinics on Wheels, microplanning occurs monthly and targeted areas, that are over 4km from the nearest facility, are selected in close consultation with EPI staff. Microplanning for regular outreach and Clinics on Wheels suffers from a lack of financial support, often leaving health workers to cover printing, stationery, and fuel costs for activities. However, for integrated outreach activities, these costs were budgeted for and provided by implementing partners.

Community mobilization

Community mobilization strategies range from passive approaches at fixed sites to recruiting volunteers specifically for community mobilization during integrated outreach activities. Fixed-site service delivery relies predominantly on passive mobilization through opportunistic counseling when mothers visit facilities. Regular outreach employs a more structured engagement including door-to-door visits, mosque announcements, and community meetings, though frequency varies across districts. Lady Health Workers (LHWs), salaried public health staff responsible for delivering community care within assigned areas, play a key role in supporting community mobilization during regular outreach, integrated outreach, and Clinics on Wheels activities. Community mobilization is generally better resourced in urban settings. In Karachi West, for example, community-based vaccinators or social mobilizers are used routinely to engage in door-to-door visits as part of regular outreach. Integrated outreach activities deployed additional voluntary social mobilizers to systematically support demand generation along with LHWs. Clinics on Wheels utilizes professional social mobilizers for daily mosque announcements, influencer meetings, and targeted door-to-door visits. During polio house-to-house campaigns, polio workers are paired with local community mobilizers to carry out one-on-one counseling. The mobilizers visit communities before campaign days to inform families about the upcoming polio workers visits.

Service delivery

Vaccine delivery strategies in Pakistan vary considerably, with some operating under significant resource and staffing constraints, while others benefit from comparatively greater funding and support. For fixed-site delivery, children are vaccinated at the facility, where a permanent cold chain is maintained and vaccinators benefit from support of facility-managers, midwives, and Lady Health Visitors (LHVs). The latter are a cadre above LHWs and provide clinical care. Regular outreach extends vaccine delivery through established outreach sites which vaccinators visit, as per the microplan, and provide immunization services in community. For both regular and integrated outreach activities, vaccinators almost exclusively rely on motorcycles. In the case of the former, many vaccinators reported that fuel allocation was not sufficient, and no staff received per diem. LHWs numbers are limited, and many sites, especially in rural areas, operate without LHW support, sometimes leaving vaccinators to shoulder both service delivery and community engagement responsibilities alone during regular outreach. Integrated outreach activities are intensive and time-bound vaccination drives. Dedicated funding is provided for integrated outreach activities for travel and per diem, however, some funding gaps persist as a number of sites reported constraints for transport similar to those for regular outreach. Clinics on Wheels primarily conduct service delivery at urban slums or nomadic settlements, and while staff receive regular salaries, they do not receive additional per diem for the visits. In contrast, polio house-to-house campaigns receive substantially greater financial and logistical support, including per diem and transport provisions.

Reporting

Both provinces utilize standardized reporting systems, yet data integration remains fragmented across interventions. Routine immunization data from fixed-site delivery and regular outreach are recorded directly in electronic databases—Zindagi Mehfooz in Sindh and EMR in Punjab. In parallel, reporting is captured manually through daily registers, permanent registers, and tally sheets. Clinics on Wheels carry out the same manual reporting as routine strategies and share data with EPI for the EMR. For integrated

outreach activities, manual daily registers are utilized and fed into the EMR and Zindagi Mehfooz databases in Punjab and Sindh respectively. Polio house-to-house campaigns are also managed on separate electronic systems for each province, with Punjab using a platform called Synergy and Sindh relying on Google Sheets formatted locally. During the campaigns, polio workers record zero-dose children on manual tally sheets, which are subsequently uploaded to the electronic system each evening, and then shared between PEI and EPI. EPI staff access these data through a mobile application to obtain a list of zero-dose children for follow-up for vaccination and tracking. The coexistence of manual and digital systems has resulted in a substantial documentation burden on staff. EPI staff report challenges with the zero-dose data reported by PEI, including inaccurate and missing information.

Financing and partner support

Routine strategies are funded and implemented by the government, while selected interventions operate through government platforms with technical and financial support from partners and donors. Routine outreach and fixed site are the primary responsibility of the EPI, while integrated outreach activities operates within a multi-partner framework, with Gavi providing financial support, WHO delivering technical guidance, and UNICEF contributing communication materials and community mobilization resources. Clinics on Wheels is a Government of Punjab initiative that is primarily funded by the government. The government oversee operations, WHO provides technical guidance and some contractual staff, and UNICEF contributes through demand-generation support. Polio-house-to-house campaigns benefit from substantial donor financial and technical support, particularly from WHO and UNICEF. Operational funding channeled to sites through District Health Offices remains severely inadequate with rural districts reporting fuel shortages and delayed disbursements. Budget flexibility varies significantly across districts, with sites in Karachi West reporting high flexibility, whereas sites in Punjab indicated that financial allocations were fixed with adjustments permitted only during emergencies.

4.2 ROOT CAUSES OF ZERO-DOSE PREVALENCE

Interviews with service providers also revealed critical supply- and demand-side barriers for reaching zero-dose children in Pakistan, and these challenges differ across settings and districts. These barriers interact differently depending on the local context, and a summary of context-specific barriers by district is provided in Table 3.

Human Resource Challenges:

Human resource shortages are a critical barrier to zero-dose reduction in both provinces, with single vaccinators often responsible for large catchment areas. Urban districts such as Lahore, Karachi, and Faisalabad face challenges in reaching large populations living in informal settlements, slums, or marginalized communities that are often poorly mapped. In contrast, rural areas such as Ghotki and Qambar Shahdadkot contend with vast and scattered populations that are difficult to access. Heavy documentation burdens reduce vaccinator efficiency and a shortage or unavailability of Lady Health Workers weakens social mobilization efforts as vaccinators rely heavily on LHWs for community engagement. Further, female vaccinators are constrained in culturally sensitive areas without male team members.

Infrastructure and Resource Gaps:

Logistic and infrastructure barriers hinder reaching zero-dose children, creating lost vaccination opportunities. These challenges include inadequate outreach venues, weak supply chains, insufficient transportation, and fuel shortages. Rural areas face more fundamental infrastructure gaps, limited resources to overcome seasonal accessibility challenges and vaccination supply distribution limitations

across remote locations. The most widespread barrier across all settings is the lack of transport and fuel support, with vaccinators reporting years without adequate resources.

Knowledge & Awareness Shortfalls:
Service providers in rural areas often described how low literacy levels, combined with limited health-seeking behaviors, hinder immunization acceptance. Urban areas face different knowledge challenges, where literacy levels may be higher but diverse populations bring varying cultural belief systems that can at times conflict with modern medicine.

Poverty:
Health providers noted that families facing economic hardship often prioritize daily survival over health services, and sometimes demand goods or services in exchange for acceptance of vaccination. Financial constraints also limit their ability to travel to facilities and access services.

Beliefs, Norms, and Practices:
Community beliefs and practices around vaccination shows both similarities and contextual differences across provinces. In Punjab, service providers commonly reported misconceptions such as doubts about vaccine effectiveness and uncertainty about benefits, while in Sindh they described more deep-rooted community norms contributing to resistance. For example, in some Pathan and Afghan refugee communities in Karachi West, families observe a 40-day period of post-partum confinement intended as postnatal protection of the infant, which can delay early contact with immunization services. In both provinces, religious objections and injection fears were more commonly reported in rural areas, whereas in urban areas, health personnel often reported about caregivers concerns related to fertility myths and vaccine safety.

Migration & Mobility Challenges:
Migration patterns differ substantially between provinces and urban-rural settings. Punjab facilities emphasize economic migration patterns, particularly industrial development driving population movement that complicates service delivery. Mobile populations in industrial areas create significant challenges for maintaining immunization records and ensuring service continuity. Sindh faces more complex migration dynamics, including seasonal patterns where populations migrate from other provinces during winter, returning in summer. This seasonal movement significantly disrupts immunization efforts, with children receiving initial vaccines locally but becoming defaulters for subsequent doses when families return to origin villages.

Service experience and quality:
Caregivers often feel coerced during vaccination encounters, particularly in campaigns where frequent visits and pressure create negative experiences that drive resistance. Dissatisfaction with vaccinators' attitudes and service quality further contributes to avoidance or refusal. These issues are more pronounced in diverse ethnic communities, where culturally insensitive approaches heighten mistrust. Service providers also noted that they felt discouraged to open multi-dose vials when a few children were present, leading to missed vaccinations and underscoring inadequate training.

Table 3. Barriers to reaching zero-dose children, by district

District name	Province	Rural/urban	Key barriers
Karachi West	Sindh	Urban	– **Large presence of Pathan and Afghan communities**. Pathan families refuse vaccination during a 40-day

			post-birth home confinement period, so can miss or delay their initial touch point with health providers. – **Campaign overload**: Families feel overwhelmed and pressured during vaccination campaigns, which creates suspicion and cause them to develop resistance to both routine immunization and polio efforts
Qambar Shadakot	Sindh	Rural	– **Weather-related access barriers:** Heavy rainfall creates impassable terrain preventing vaccinator access to scattered communities – **Limited human resources:** One vaccinator serves large catchment areas with difficult terrain and population dispersion – **Myths**: Population specifically distrusts vaccines believing they cause infertility by making children unable to reproduce
Ghotki	Sindh	Rural	– **Limited human resources:** As noted above – **Seasonal migration:** workers and their families arrive for cotton picking season and then depart, disrupting vaccination schedules mid-cycle – **Myths:** Religious leaders systematically disseminate negative vaccine information and accentuate side effect concerns
DG Khan	Punjab	Rural	– **Poverty:** Families struggle to meet widespread daily needs and demand goods or services in exchange for vaccination acceptance – **Migration:** Migrant populations from Khyber Pakhtunkhwa create language related communication challenges about vaccination benefits – **Weather-related access barriers:** Riverine and flooded areas become completely inaccessible during certain periods
Lahore	Punjab	Urban	– **Access constraints:** Many residents are daily wage workers and are unavailable during standard vaccination visit times – **Population:** Dense communities with different languages complicate vaccination communication and tracking
Faisalabad	Punjab	Urban	– **Population:** Mobile populations driven by industrial employment create challenges in immunization record maintenance due to their movement between cities

			– **Limited human resource:** Limited staffing, particularly for social mobilization, hinder vaccination services – **Settlements barrier:** Informal settlements with rural migrants and high hesitancy
Bahawalnagar	Punjab	Rural	– **Weather-related access barriers:** Hard-to-reach riverside communities become completely cut off following heavy rains – **Resource and logistics constraints:** Vaccinators report no fuel or field work support for several years, preventing community reach

4.3 ENABLING FACTORS AND CHALLENGES, BY INTERVENTION

Key enablers and challenges affecting identification and vaccination of zero-dose children thought the strategies assessed in this study are summarized below:

Table 4. Enablers and challenges for identifying and reaching zero-dose children

Strategy	Enablers	Challenges
Fixed site	Health facilities serve as permanent locations where families can seek vaccination services at predictable times Additional healthcare services available, which can boost demand	Cultural practices including postpartum confinement and home deliveries reduce facility utilization Health facilities located far from rural communities limit accessibility for vaccination services
Regular outreach	Microplans that specifically target certain hard-to-reach geographic areas, especially those that are hard to reach Lady Health Workers drive community social engagement and mobilization Leveraging polio house-to-house records enhances outreach by improving the efficiency of microplanning	Inadequate staff deployment to cover catchment area Low financial support for travel hinders the coverage of outreach
Integrated outreach activity	Targeted data-informed microplanning for low-coverage areas before every campaign Voluntary trained social mobilizers inclusion along with Lady Health Workers	Campaign fatigue among community generate resistance to vaccination efforts Triple documentation burden on vaccinators limit their ability to identify and track zero-dose children effectively

	Per diem incentives for staff and travel allowances allow teams to travel further into the communities	
Clinics on Wheels	The mobility of Clinics on Wheels enables them to deliver services to the most disadvantaged areas Provision of additional services improves demand for immunizations	Very limited access to polio-data on zero-dose children High demand for services, with long queues and vans overcrowded
Polio house-to-house campaigns	Polio campaigns are heavily resourced, with large numbers of dedicated teams The door-to-door nature of campaigns allows teams to identify children who have been missed	Data quality issues (i.e. wrong addresses and mobile numbers recorded) affect EPI microplanning Campaign fatigue among community generate resistance to vaccination efforts

5. QUANITATIVE FINDINGS

5.1 CHILDREN REACHED AND DOSES DELIVERED

Integrated outreach activities demonstrated the highest daily delivery of routine immunization doses, averaging 97 doses per Union Council (Table 5). Daily volume delivered of any routine antigen was consistently high across both rural (92) and urban (102) settings. Regular outreach followed with an average of 70 daily doses, showing greater effectiveness in urban areas (88) compared to rural contexts (51). Fixed-site delivery and Clinics on Wheels contributed far fewer daily doses, averaging 34 and 33 per Union Council, respectively. Clinics on Wheels delivered an average of 382 services per day across sampled sites, highlighting its role in integrated service delivery rather than as a high-volume immunization strategy.

Table 5. Average doses delivered by Union Council per day (min-max)

Intervention *(sample size)*	**ALL**	**RURAL**	**URBAN**	**Average number of days operated per month**
Fixed site delivery *(23 Union Councils)*	34 *(2-86)*	34 *(5-81)*	35 *(2-86)*	26
Regular outreach *(23 Union Councils)*	70 *(10-148)*	51 *(10-142)*	88 *(22-148)*	24
Integrated outreach activity *(23 Union Councils)*	97 *(29-170)*	92 *(40-170)*	102 *(29-165)*	22 (Punjab) 12 (Sindh)
Clinics on Wheels *(2 Union Councils)*	33 *(25-41)*	*N/A*	33 *(25-41)*	26

The number of zero-dose children identified each day through polio house-to-house campaigns per Union Council ranged from 1.1 to 2.3 (Table 5). Fewer zero-dose children were identified in the October 2024 campaign compared to the November 2023 campaign, averaging 1.1 per Union Council per day in 2024 versus 2.3 in 2023. These findings suggest that the effectiveness of this strategy may be declining over time, likely because the remaining zero-dose children are increasingly difficult to reach. The data also reveal a clear urban–rural disparity, as in the October 2024 campaign substantially more zero-dose children were identified in urban Union Councils (1.6 per day), compared to in rural areas (0.6 per day). Additional analysis on identification of zero-dose children through house-to-house polio campaigns is detailed in a separate publication.[10]

Table 6. Average zero-dose children identified by Union Council per day (min-max)

Intervention	ALL	RURAL	URBAN	Average number of days operated per month
Nov 2023: Polio house-to-house campaign *(24 Union Councils)*	2.3 *(0-21)*	1.2 *(0-8)*	3.5 *(0-21)*	5 (Rural) 7 (Urban)
Oct 2024: Polio house-to-house campaign *(24 Union Councils)*	1.1 *(0-9)*	0.6 *(0-2)*	1.6 *(0-2)*	5 (Rural) 7 (Urban)

Integrated outreach activities reached more zero-dose children, though its coverage was not substantially greater than that of regular outreach (Table 7). On average, integrated outreach activities reached just over one zero-dose child per Union Council per day, performing slightly better in rural areas (1.4) than in urban areas (1.2). Both regular outreach and Clinics on Wheels each reached about 0.7 zero-dose children daily; regular outreach was marginally more effective in urban areas (0.8) compared to rural areas (0.6). Fixed-site delivery was the least effective strategy, reaching only 0.3 zero-dose children per day across both rural and urban settings.

Table 7. Average zero-dose children reached by Union Council per day (min-max)

Intervention	ALL	RURAL	URBAN
ZERO-DOSE CHILDREN REACHED			
Fixed site delivery *(19* Union Councils)*	0.3 *(0-2.2)*	0.4 *(0-2.2)*	0.3 *(0-1.1)*
Regular outreach *(21* Union Councils)*	0.7 *(0-2.2)*	0.6 *(0.1-1.3)*	0.8 *(0-2.2)*
Integrated outreach activity *(21* Union Councils)*	1.3 *(0.05-5.3)*	1.4 *(0.05-5.1)*	1.2 *(0.1-5.3)*

Clinics on Wheels *(2 Union Councils)*	0.7 *(0.2-1.2)*	N/A	0.7 *(0.2-1.2)*
DOSES DELIVERED			
Fixed site delivery *(23 Union Councils)*	34 *(2-86)*	34 *(5-81)*	35 *(2-86)*
Regular outreach *(23 Union Councils)*	70 *(10-148)*	51 *(10-142)*	88 *(22-148)*
Integrated outreach activity *(23 Union Councils)*	97 *(29-170)*	92 *(40-170)*	102 *(29-165)*
Clinics on Wheels *(2 Union Councils)*	33 *(25-41)*	*N/A*	33 *(25-41)*

**For two Union Councils the electronic data was not available to derive zero dose numbers*

5.2 COST FINDINGS

Identifying zero-dose children

The average incremental cost of identifying zero-dose children during polio house-to-house campaigns was estimated between $9.24 and $17.21 per zero-dose child identified, consisting solely of the opportunity cost of staff and volunteer time (See Figure 1 and Box 2). This cost reflected the additional time spent by staff and volunteers on identifying zero-dose children and reporting them into the joint electronic registry shared between PEI and EPI. On average, it was estimated that each personnel working on the campaign spent an extra 82 minutes per day on the zero-dose initiative. At the implementation level, no additional financial costs (such as extra per diem and fuel) were spent in relation to the incorporation of zero-dose identification into the campaigns. The cost incurred per zero-dose child identified was lower for the November 2023 campaign ($9.24) than for the October 2024 campaign ($17.21), driven by the higher volume of children identified in the earlier campaign (2.1 per day vs 1.1 per day).

Box 2 – Portion costed for each intervention

Polio house-to house campaigns
Incremental cost of zero-dose identification and reporting

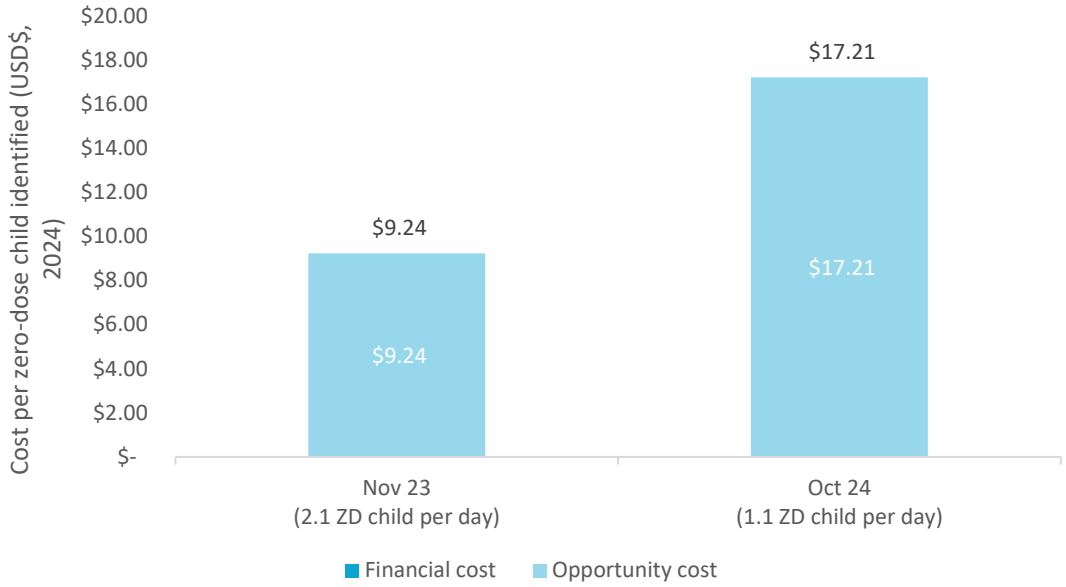
Fixed site
Full cost on immunization session

Regular outreach
Full cost on immunization session

Integrated outreach activities
Full cost on immunization session

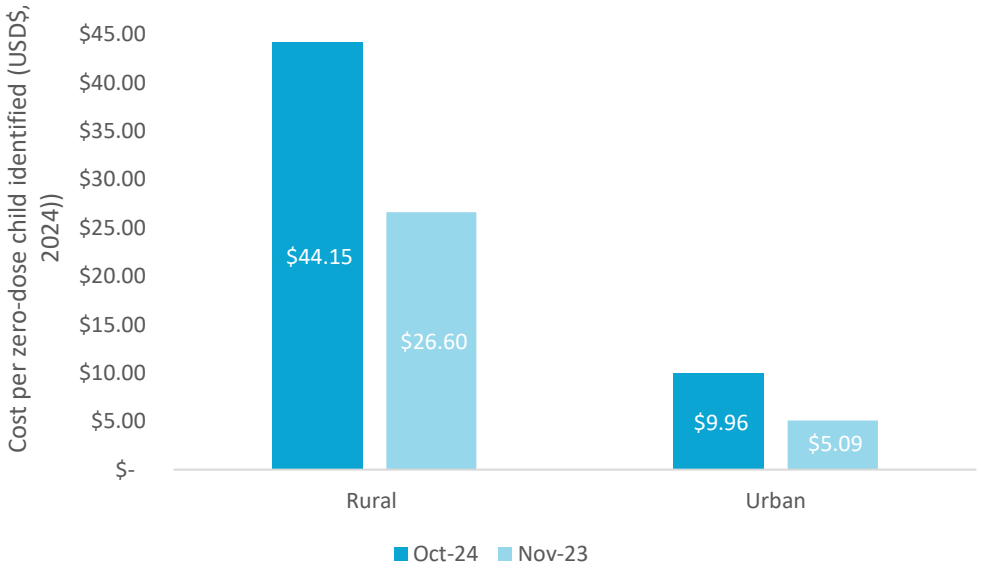
Clinics on Wheels
Incremental cost of immunization portion

Figure 1: Average economic cost per zero-dose child identified through polio house-to-house campaigns



The incremental identification cost was higher in rural areas, ranging from $26.60 to $44.15, compared to $5.06-$9.09 in urban areas, where far more zero-dose children were identified (Figure 2). Similarly, this difference is primarily driven by the volume of zero-dose children identified. In rural areas, over half of the number of zero-dose children were identified per day during polio house-to-house campaigns, compared to urban areas (0.6 vs 1.6 in October 2024 campaign). Findings highlight that rural settings, marked by vast territories, geographic isolation, and weather-related access barriers, face greater difficulty delivering intensive door-to-door campaigns as efficiently as urban areas.

Figure 2: Average economic cost per zero-dose child identified through polio house-to-house campaigns, by geographic location

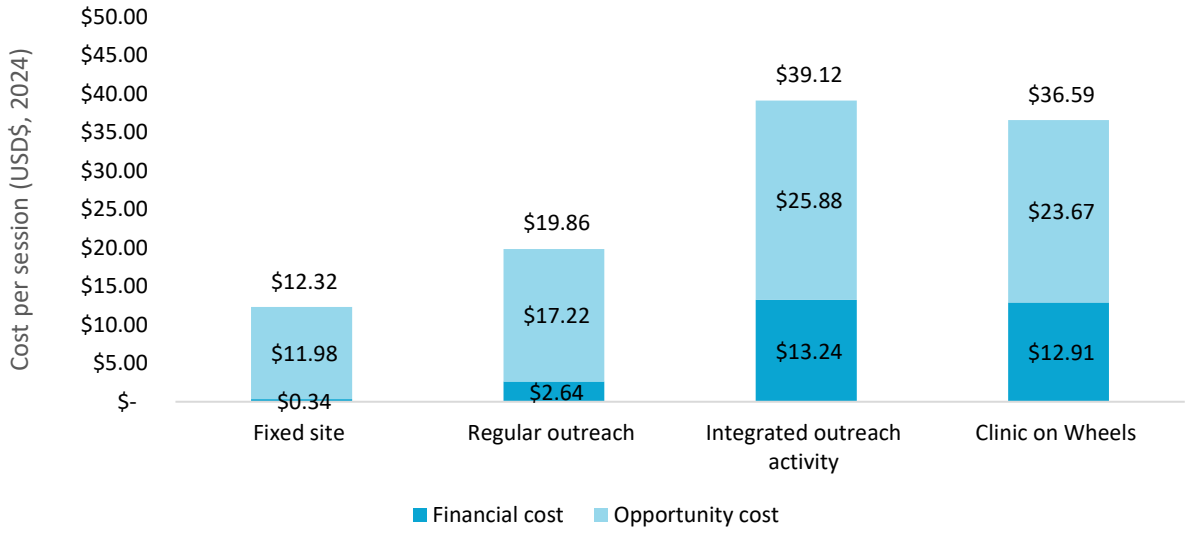


Vaccinating zero-dose children

Cost per session

At Union Council level, routine strategies were less costly per session compared with zero-dose focused interventions (Figure 3). Across all delivery strategies, fixed-site delivery incurred the lowest cost per session, at $12.32. Fixed-site services require minimal transport infrastructure since staff work on-site. In contrast, integrated outreach activities recorded the highest economic cost per session, averaging $39.12 per session with a $13.24 financial cost. This intervention had higher levels of financial and human resource support compared with routine strategies, including per diem and travel allowances for personnel, as well as the involvement of a volunteer social mobilizer working alongside the vaccinator. Even when only considering the incremental cost of the immunization component, Clinics on Wheels sessions were more expensive than routine sessions due to the extensive human resources involved in community mobilization efforts, including Lady Health Workers, Social Mobilizers, and Sanitary Patrols.

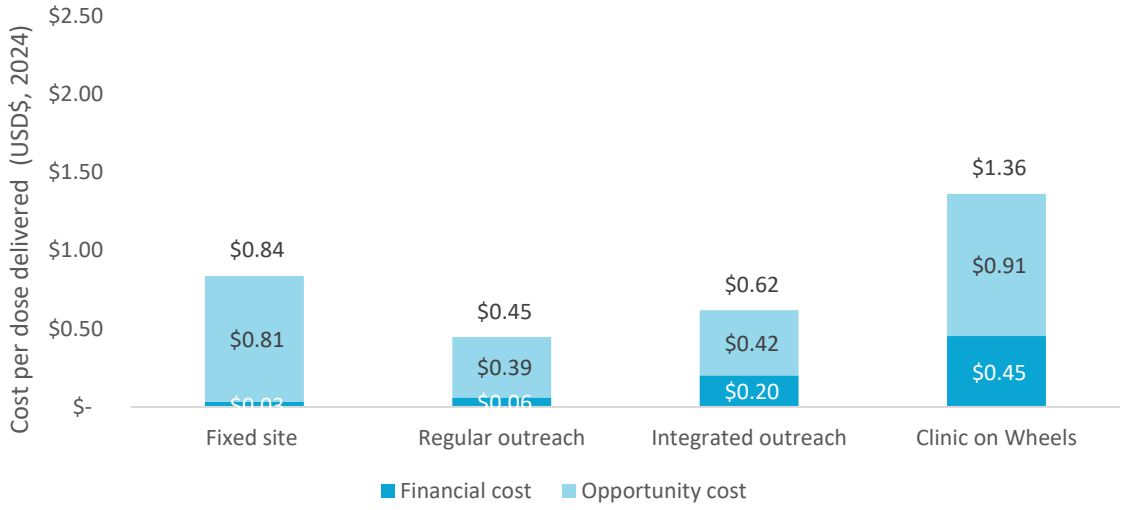
Figure 3: Average economic cost per session, by delivery strategy



Cost per dose

At $0.45 per dose for any antigen, regular outreach incurred the lowest economic cost per dose aggregated at each compared with fixed-site and targeted zero-dose strategies (Figure 4).
While regular outreach required additional resources to go out into the community—such as vehicles, transport, per diem, and communication—which were not required at fixed sites, due to the high delivery volumes they achieved, costs were lower on a per dose basis. Staff received no additional compensation for regular outreach, and at some sites, they covered fuel and printing expenses out of pocket, contributing to a small financial cost of $0.06 per dose. In contrast, Clinics on Wheels had the highest cost per dose at $1.36, including immunization-related costs only. This higher cost was due to strategy being relatively better resourced, as well as due to the with lower delivery volumes (33 per day compared with 97 for integrated outreach), resulting in a relatively higher per-dose cost.

Figure 4: Average economic cost per dose, by delivery strategy

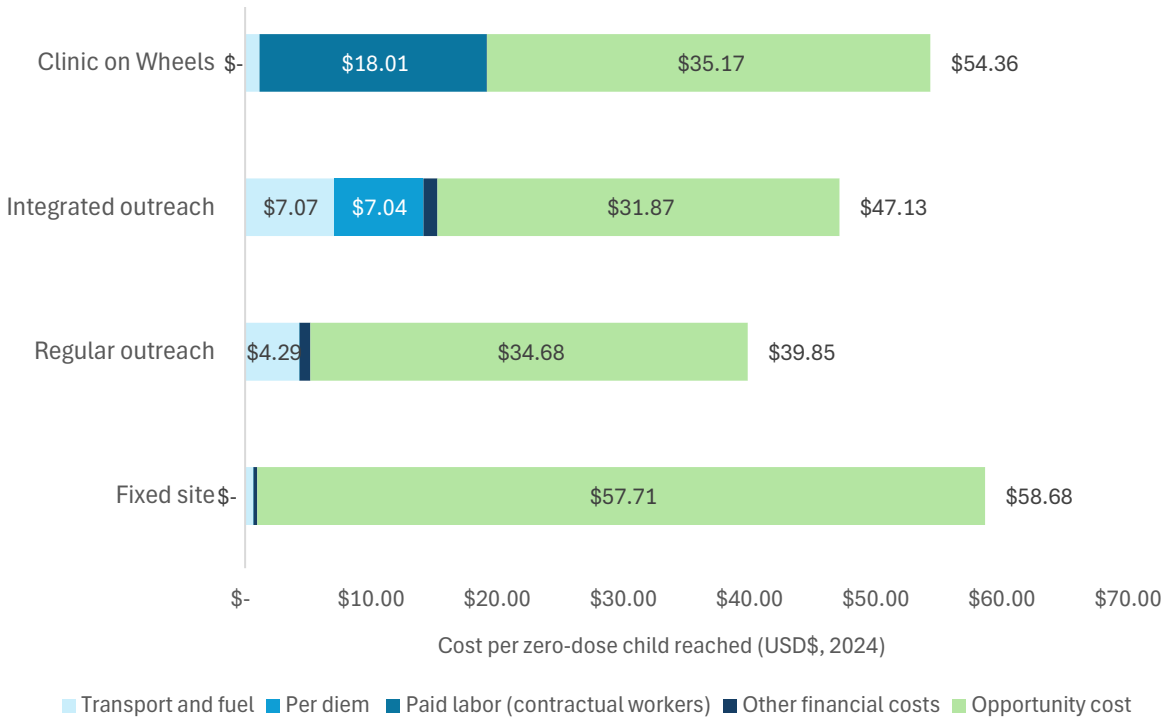


Cost per zero-dose child reached

Regular outreach also incurred the lowest economic cost per zero-dose child reached compared with other strategies (Figure 5). Economic costs per zero-dose child ranged from $39.85 for regular outreach, $47.13 for integrated outreach activities, $54.36 for Clinics on Wheels, and peaked at $58.68 for fixed-site delivery. Despite reaching slightly more zero-dose children per day than regular outreach (1.3 vs 0.7 per day respectively), we found that overall integrated outreach activities were not more cost-efficient.

The primary drivers of financial costs varied by strategy, while opportunity costs across all strategies consisted primarily of the value of health worker salaries (Figure 5). For regular outreach, transport and fuel, at $4.25, was the main financial cost driver. For integrated outreach activities, financial costs were predominantly split between transport and fuel ($7.07) and per diem ($7.04). For Clinics on Wheels, the key financial cost driver related to contractual staff hired on short-term contracts by development partners, amounting to $18.01. Across all strategies, opportunity costs represented the largest share of total economic cost, ranging from 65% for Clinics on Wheels to 98% for fixed-site delivery. In all cases, paid labor, specifically the salaries of existing staff, was the largest component of these opportunity costs.

Figure 5: Average economic cost per zero-dose child reached with Penta 1, by delivery strategy



Integrated outreach activity was a relatively more cost-efficient strategy in rural areas, whereas routine outreach proved more cost-efficient in urban areas (see Figure 6). Consistent with trends observed for the identification of zero-dose children, the cost of reaching zero-dose children was higher in rural areas for both regular and integrated outreach compared with urban areas. In rural settings, integrated outreach incurred a slightly lower cost than routine outreach per zero-dose child, while in urban areas, the opposite pattern was observed, with routine outreach being less costly than integrated outreach per zero-dose child ($28.66 vs. $33.81). Though it should be noted that labor is a key cost-driver which is self-reported time spent, some of the observed differences in cost may partly reflect variation in how time was estimated.

Figure 6: Average economic cost per zero-dose child reached with Penta 1 through outreach, by geographical location

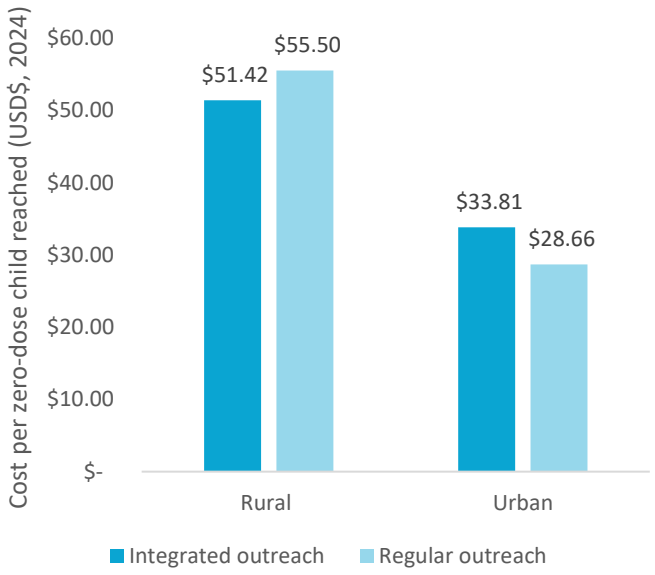


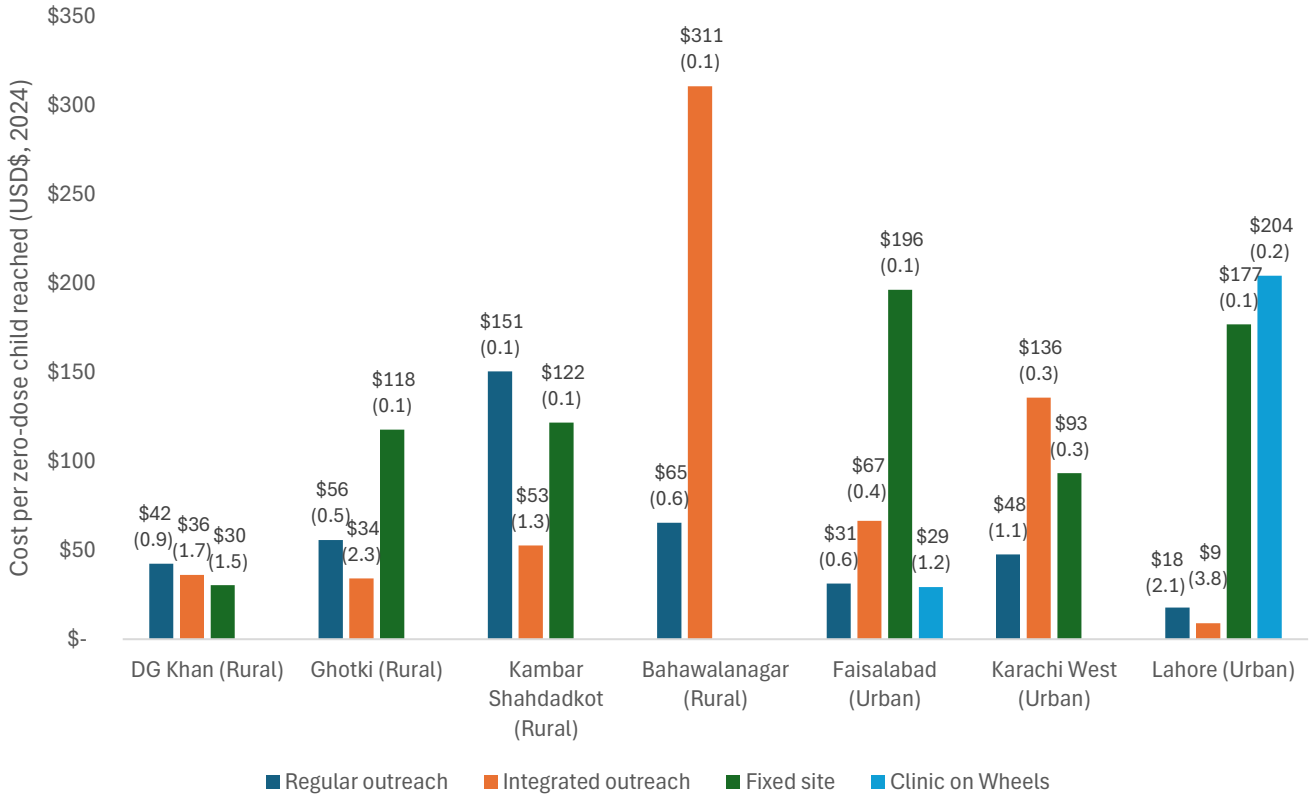
Table 8: Summary of economic cost by intervention by session, dose, and ZD child reached

Intervention	Cost per session	Cost per dose	Cost per ZD child reached
Fixed site delivery	$12.32	$0.84	$54.36
Regular outreach	$19.86	$0.45	$39.85
Integrated outreach activity	$39.12	$0.62	$47.13
Clinics on Wheels	$36.59	$1.36	$58.68

Cost per zero-dose child reached: Subnational analysis

The effectiveness and efficiency of each intervention vary based on their ability to address the main drivers of zero-dose prevalence in the context where it is implemented, as reflected by the substantial variation in costs across districts for different strategies (See Figure 7). The considerable cost variation between interventions across districts, for the most part, reflects differences in the number of zero-dose children reached.

Figure 7: Average economic cost per zero dose child reached with Penta 1, by district (zero-dose children reached per day in brackets)



Barrier: Supply-side gaps

In three of the four rural districts, integrated outreach achieved a lower cost per zero-dose child reached, as it addressed critical human and financial resource gaps and enabled substantially higher coverage than routine outreach (1.4 vs. 0.6 children per Union Council, per day). For example, in rural Ghotki, the cost per zero-dose child reached was $34 for integrated outreach compared with $56 for routine outreach. In some sites in Ghotki and Qambar Shahdadkot, a single vaccinator serves entire large catchment areas without any community-mobilization support from Lady Health Workers. In these instances, the involvement of a volunteer social mobilizer during integrated outreach significantly enhanced outreach efficiency. In one out of the four rural districts, Bahawalnagar, the cost of integrated outreach was higher per zero-dose child reached. In this district, severe weather-related access barriers during integrated outreach greatly limited vaccinators' ability to reach zero-dose children, resulting in an extremely high cost per zero dose child at $311.

Barrier: Hesitancy and mistrust

In two of the three urban districts, regular outreach delivered the lowest cost per zero-dose child reached, highlighting the comparatively limited effectiveness of integrated outreach activities. This was particularly evident in urban Karachi West, an area marked by large migrant populations and high levels of mistrust. Here, regular outreach was better resourced than other districts, with voluntary community mobilizers routinely supporting regular outreach efforts, resulting in a cost of $48 per zero-dose child reached compared to $138 for integrated outreach. Qualitative insights revealed widespread 'campaign fatigue' among caregivers, coupled with frustration over government neglect of broader community needs, which fueled resistance to intensive campaign-style approaches. In contrast, in this district, routine outreach demonstrated its potential to build and maintain trusting relationships with communities.

Barrier: Poverty

In DG Khan, fixed-site delivery emerged as a relatively cost-efficient strategy, with financial incentives boosting zero-dose reach above average levels in poverty-affected contexts. The district reported a higher daily number of zero-dose children reached through fixed site, compared to the overall average (1.5 vs. 0.3) shown in Table 7. At $30 per zero-dose child reached, fixed-site delivery was more cost-efficient than regular outreach ($36) and integrated outreach ($40). The qualitative findings suggest that the Aghosh maternal and child health conditional cash transfer program contributed to this outcome, as mothers were reimbursed per measles-rubella (MR) vaccine dose when accessing this vaccine at facilities.

Barrier: Accessibility

Clinics on Wheels proved much more cost-efficient in Faisalabad than in Lahore, reflecting differences in the distribution of zero-dose children. In Faisalabad, where newly established housing societies and mobile rented populations linked to industrial employment create concentrated informal settlements, the cost was just $29 per zero-dose child reached, which was the lowest among all delivery strategies. By contrast, in Lahore, where zero-dose populations are highly dispersed and service accessibility is generally greater than Faisalabad, the cost was $204. With a cost of $29 per zero-dose child reached, Clinics on Wheels was among the more cost-efficient strategies in Faisalabad, closely comparable to routine outreach at $31 in the same district. These findings highlight that Clinics on Wheels are better suited to contexts with concentrated zero-dose populations, such as informal or transient settlements.

6. KEY TAKEAWAYS

- **To be most effective at reaching zero-dose children, the immunization strategies must match the specific zero-dose barriers of the context where they are implemented,** whether that be addressing community resistance, routine infrastructure gaps, poverty, or accessibility. For example, while fixed-site delivery was generally inefficient in reaching zero-dose children, in DG Khan, financial incentives at facilities helped boost zero-dose reach of fixed-side delivery by addressing poverty as the predominant barrier.

- **Immunization outreach campaigns, such as integrated outreach activities, should be strategically deployed only where routine delivery is constrained, and not as a blanket intensification of service delivery across provinces**. Integrated outreach activity was more effective in rural areas, where routine services are hindered by shortages of staff, limited funds for fuel and transport, or other operational barriers, that outreach campaigns help address. In better-resourced urban areas, routine outreach offers greater cost-efficiency, as informants shared that vaccine hesitancy poses a more significant barrier to reaching zero-dose children than supply-side challenges in these settings. Routine outreach's continuity of services helps build trust that more effectively helps tackle this challenge.

- **Clinics on Wheels is a highly targeted intervention, most effective in areas where zero-dose children are concentrated in informal settlements. However, it is relatively high-cost compared to outreach.** Informal settlements represent a context where Clinics on Wheels can be particularly impactful, but this intervention is not suitable for widespread scale-up given the higher operational costs and intensive staffing requirements, which make it less efficient in areas where zero-dose children are fewer or more dispersed.

- **Integrating zero-dose identification into polio house-to-house campaigns is relatively efficient, as it requires no additional financial costs.** However, identification is one piece of the jigsaw, and reaching these children depends on the effectiveness of the underlying service delivery interventions. While these campaigns provide a valuable microplanning tool for the EPI, they remain costly and heavily donor-dependent, and their efficiency may be declining over time as the number of easily identifiable zero-dose children decreases. Strengthening EPI microplanning is therefore essential to prepare for a future transition away from polio campaigns.

- **Regular outreach has strong potential for reaching zero-dose children if adequately resourced with sufficient human resources, effective microplanning, and reliable financing for transportation and logistics**. Overall, we found that regular outreach incurred the lowest cost per zero-dose child reached. When these conditions are met, regular outreach can serve as the backbone for extending immunization to missed and underserved communities within routine delivery systems. Strengthening outreach also reinforces continuity of services and fosters community trust more effectively than temporary campaign-style interventions.

7. ANNEXES

ANNEX 1. PROGRAM ACTIVITIES AND RESOURCE TYPES DEFINITIONS

Table 9. Program activities definitions

Activity	Definition
Microplanning	Time and resources spent mapping, estimating target populations, identifying hard-to-reach groups, planning session sites, assigning resources, and scheduling vaccination activities.
Other program management	Time and resources spent on planning, budgeting, managing the immunization outreach program at various levels. This may include the cost of time and resources spent on forecasting vaccine needs. Costs will include attendance at immunization-related meetings.
Vaccine collection, distribution and storage	Time and resources spent collecting vaccines and other commodities at distribution points and distributing vaccines down to the fixed posts and to the outreach sites.
Cold chain maintenance	Time and resources spent maintaining the cold chain at each level.
Training	Time and resources spent attending and/or providing immunization-related training. Training costs include the cost of venue, per diem for participants, cost of trainers, and reproduction of training materials.
Social mobilization and advocacy	Social mobilization includes holding community meetings, printing flyers and educational materials, conducting events, other sensitization of the community. Includes any time and resources spent mobilizing the community and households, and advocating for vaccination (value of time, per diem, cost of materials, etc.). This could include the cost of media advertisements.
Supervision	Time and resources spent by facility, district, or province level staff on supervising subordinate or peer health or community workers for outreach delivery.
Service delivery:	Time and resources spent on the act of administering vaccination to children during an immunization session
Service delivery: other strategies	Time and resources spent on traveling to and from a place and the act of administering vaccination to children through other strategy or strategies used
Waste management	Time and resources spent on disposing used vials/bottles, sharps and infectious non-sharp wastes.
AEFI management	Time and resources spent following-up post-vaccination events that may occur during immunization.
Record-keeping, HMIS, monitoring and evaluation	Time and resources spent on data entry and analysis, including maintaining stock registers, maintaining records of children vaccinated, completing reports and analyzing, monitoring, and evaluating immunization program data.

Table 10. Resource type definitions

Resource types	Description	Financial vs. opportunity cost
Recurrent resource types		
Paid labor	Share of the salary paid to health workers and government employees proportional to the time they spent working on activities related to the intervention	Opportunity cost
	Salary paid to temporary workers, contractual workers, or new employees hired specifically for the delivery strategy	Financial cost
Volunteer labor	Value of volunteer labor (community health volunteers, voluntary social mobilizers) who do not receive a regular salary.	Opportunity cost
Workshops & meetings	Food, beverages, and meals provided to regular and volunteer staff.	Financial cost
Per diem and allowances	Daily allowances and/or subsidies and travel allowances paid to regular employees and volunteers for participation in activities related to the intervention	Financial cost
Transport and fuel	Fuel costs specifically for activities that required travelling (supervision, trainings, vaccine distribution, etc.)	Financial cost
Vehicle maintenance	Routine and non-routine vehicle maintenance done during the study period	Opportunity cost
Cold chain equipment repairs and energy costs	Routine and non-routine cold chain maintenance/repairs done during the study period	Opportunity cost
	Electricity bill for the cold chain	Opportunity cost
Communication	Costs incurred for internet and cellular data used by paid or volunteer staff, promotional and advertising costs.	Financial cost
Capital items		
Cold chain equipment	Depreciation costs of existing cold chain equipment used for the delivery strategy	Opportunity cost
Vehicles	Depreciation costs of existing vehicle(s) used for the delivery strategy (trainings, supervision, vaccine collection/distribution) at study sites.	Opportunity cost

Resource types	Description	Financial vs. opportunity cost
Other equipment	Depreciation costs of existing equipment items used for the delivery strategy	Opportunity cost

ANNEX 2. THEMATIC ANALYSIS SUMMARY

Theme	Sub-themes
Planning and target setting	1. Delivery strategy specific microplanning 2. Quarterly vs annual cycles for planning. 3. Zero-dose data integration as part of planning
Service delivery modalities	1. Facility-based delivery vs community based 2. Static vs mobile 3. Time-bound vs routine delivery. 4. Door-to-door vs outreach sites
Reaching communities and social mobilization	1. Passive opportunistic counselling 2. Active pre-session engagement 3. Systematic house-to-house mobilization 4. Professional and training-based mobilization 5. Zero-dose data directed targeted mobilization
Transportation and logistics	1. Minimal facility-based transport needs 2. Dedicated campaign planned transportation 3. Urban-rural vehicle disparities. 4. Personal cost absorption by staff 5. Zero-dose reach limitations due to transport barriers
Data and record keeping	1. Multiple digital platform usage 2. Manual record keeping 3. Real-time vs end-of-campaign reporting 4. Urban-rural technological disparities 5. Zero-dose tracking systems;
Financing	1. Domestic funding 2. Donor campaign support 3. Public-private partnership models;
Resources and infrastructure	1. Facility infrastructure and cold chain maintenance 2. LHW network use 3. Additional human resource deployment 4. Mixed funding mechanisms 5. Budget flexibility variations 6. Zero-dose identification resource requirements; 7. Polio infrastructure leverage for ZD data
Daily challenges	1. Data quality and integration issues 2. Staff personal cost burden 3. Campaign extension impacts

	4. Geographic accessibility constraints 5. System sustainability concerns 6. Zero-dose definition variations 7. Bidirectional zero-dose data flow inefficiencies
Geographic and environmental factors	1. Urban-rural service delivery disparities 2. Scattered population coverage challenges 3. Flood-prone and riverine area accessibility 4. Seasonal weather impact on service 5. Hard-to-reach terrain navigation 6. Nomadic population specialized approaches

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