Using Inactivated Polio Vaccine Vaccination Campaign Coverage Insights to Strengthen Nepal's Immunization Programme

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ABSTRACT

Background

Nepal's National Immunization Programme (NIP) has made significant strides in safeguarding public health, notably through the integration of the Inactivated Polio Vaccine (IPV) in national immunization schedule, in 2014, to combat wild poliovirus serotypes. However, a global IPV shortage between 2016 and 2018 left approximately 1.46 million children unvaccinated, creating an immunity gap against Type-2 poliovirus.

Objective

To evaluate the coverage and equity of Nepal's national inactivated polio vaccine catch-up campaign (May 26 to June 8, 2024) and identify key areas needing improvement.

Method

Administrative data from all 77 districts were reviewed and analysed by province, district, and ecological zone. To address this, Nepal launched a nationwide IPV vaccination campaign from May 26 to June 8, 2024, targeting children aged between five years and eight months to eight years and months.

Result

The campaign achieved national coverage of 95.9%. However, disparities were noted: district-level coverage ranged from 45.2% in Bagmati to 124.7% in Koshi. Province-level performance varied, with Madhesh (111.6%) and Karnali (110.7%) exceeding targets, while Bagmati (88.2%) and Gandaki (75.8%) underperformed. These differences were influenced by terrain, cold chain capacity, population mobility, and urban-rural inequities.

Conclusion

Nepal's inactivated polio vaccine campaign largely succeeded in bridging the post-shortage immunity gap, but subnational disparities highlight systemic challenges. Strengthening cold chain infrastructure, improving microplanning through quality data, and tailoring outreach to underserved areas are essential to enhance equity and sustain Nepal's polio-free status.

KEY WORDS

Healthcare disparities, Immunization, Immunization programs, Inactivated poliovirus vaccine, Nepal, Vaccination coverage

INTRODUCTION

Nepal's journey toward a robust National Immunization Programme (NIP) stands as a testament to its resilience and commitment to public health. Since achieving polio-free status in 2010, the country has sustained this milestone through strategic vaccination efforts and robust nation-wide surveillance. As part of the Global Polio Eradication Initiative's Endgame Strategy, Nepal introduced the Inactivated Polio Vaccine (IPV) into its routine immunization schedule in 2014.[1] Initially administered as a single intramuscular dose at 14 weeks of age, the country transitioned to a two-dose fractional IPV (fIPV) schedule at 6 and 14 weeks in 2018 to enhance immunogenicity and reduce the risk of Vaccine-Derived Poliovirus (VDPV).

Despite these efforts, Nepal faced a significant setback due to a global IPV shortage between 2016 and 2018.[2,3] This disruption resulted in an estimated 1.46 million children born between April 2016 and October 2018 missing their IPV doses. This 'unvaccinated cohort,' representing about 5% of Nepal's total population, remained vulnerable to Type-2 poliovirus.

To close this immunity gap, the Ministry of Health and Population (MoHP), with support from Gavi, the Vaccine Alliance, WHO, and UNICEF, launched a nationwide IPV catch-up campaign from May 26 to June 8, 2024, targeting children aged 5 years 8 months to 8 years 2 months. The campaign achieved 95.9% national coverage, and marking a crucial milestone in sustaining Nepal's polio-free status.

This study analysed administrative data from Nepal's 2024 IPV vaccination campaign to examine coverage patterns and variations by province, district, and ecological zone and identify systemic challenges.

METHODS

Desk review and secondary data analysis of administrative data was conducted from integrated Health Management Information System (iHMIS).

The secondary data analysis was conducted from 26th May 2024 to 8th June 2024 in Nepal. This study analysed administrative-reported coverage data from IPV vaccination campaign, collected across Nepal's seven provinces (Koshi, Madhesh, Bagmati, Gandaki, Lumbini, Karnali, and Sudurpaschim) and its 77 districts.

The data were sourced from the MOHP via its integrated Health Management Information System (iHMIS), an online database, which aggregates vaccination records submitted by the health facilities. The final coverage validated and compiled through attested hard copies reports from all 77 districts. The dataset includes the number of IPV doses delivered during the campaign and the estimated target population per district of children born between April 2016 and October 2018, or those aged between approximately five years and eight months to eight years and two months. These target population estimates were derived from census-based projections adjusted by the local health authorities, based on household survey data.

Family Welfare Division and WHO officials were contacted for approval and permission for data use. After their approval, the protocol was submitted to Nepal Health and Research Council (NHRC), ethical board for the review and was conducted after receiving ethical clearance (Ref no: 1836).

Inclusion criteria

All 77 districts across Nepal's seven provinces (Koshi, Madhesh, Bagmati, Gandaki, Lumbini, Karnali, and Sudurpaschim) that participated in the IPV campaign.

Children born between April 2016 and October 2018 (i.e., aged 5 years 8 months to 8 years 2 months during the campaign period) targeted for the IPV catch-up vaccination campaign.

IPV coverage data reported via the integrated Health Management Information System (iHMIS) and validated through attested hard copy reports from district health offices.

Data collected and reported within the official campaign period (26 May – 8 June 2024).

exclusion criteria

Children outside the specified age range (i.e., not born between April 2016 and October 2018).

Incomplete or Unverified Data (Districts or health facilities that did not submit complete reports, submitted inconsistent or unvalidated data).

The administrative data were used as reported, without adjustments for potential over- or under-reporting. Numerator data (doses administered) were derived from campaign records submitted by health facilities, verified at the municipality and district health offices. Calculation of denominator data (target population) relied on MOHP estimates based on projection of HMIS derived from 2011 census data, which was used since the campaign was planned to vaccinate a specific cohort of approximately 1.46 million children identified as unvaccinated due to the 2016-2018 vaccine shortage. Target population estimates may be affected by inaccuracies due to, population migration, challenges in tracking births in remote areas and target population projection based on 2011 census.

The analysis synthesized national performance, provincial and district-level variations, ecological influences, and coverage gaps, offering a multi-dimensional view of campaign outcomes. Coverage rates were calculated as the percentage of the target population vaccinated, using the formula:

Coverage Rate (%)=(Number of IPV Doses Administered/ Target Population) X 100

To highlight disparities and trends, provincial-level analyses were done to assess variability within provinces, including the mean coverage, median (across districts), range, and interquartile range. Standard deviations were calculated within provinces to evaluate consistency. To examine spatial patterns, districts were grouped by Nepal's ecological zones mountains and coverage differences were analysed.

Data processing and statistical analyses were performed using Microsoft Excel 365, while spatial visualizations, including choropleth maps of provincial and district-level coverage, were generated using ArcView (GIS Software) to highlight geographic disparities.

RESULTS

National IPV Vaccination Coverage

The 2-week IPV vaccination campaign in Nepal achieved an impressive national coverage of 95.9%, consistent with the 95% coverage goal of Nepal's National Immunization Program and surpassing 90% target of WHO's Immunization Agenda 2030 by 5.9%.[4,5] This comprised administering one dose of injectable IPV vaccine to 1.40 million children (aged 5 to 8 years) out of a total target population of 1.46 million, representing 5.0% of the country's total population of 29.4 million. This achievement underscores the campaign's overall effectiveness and robust implementation throughout the nation.

Provincial IPV Vaccination Coverage

The provincial vaccination coverage across Nepal exhibited a mean of 94.9% ± 11.02% and a median of 96.0% ± 12.5% IQR, indicating a moderate degree of variability among provinces (Table 1). Notably, coverage varied significantly at the district level, ranging from a minimum of 45.2% in Ramechhap (Bagmati Province) to a maximum of 124.7% in Sunsari (Koshi Province) (Table 2). In terms of district-level performance, 4 districts achieved coverage below 60%, 23 districts ranged between 60–79%, 9 districts between 80–89%, 10 districts between 90–94%, and 31 districts surpassed 95% coverage (Table 3).

Madhesh and Karnali provinces exceeded their vaccination targets, achieving 111.6% and 110.7% coverage respectively suggesting some districts vaccinated more individuals than initially targeted, likely due to underestimated target populations. In addition, Koshi (96.0%) and Lumbini (97.0%) also performed strongly, surpassing 95% of their targets. At the provincial level, Madhesh reported the highest coverage, with a mean of 111.84% and a median of 116.3%, and all its districts achieving at least 90.6%, underscoring consistently strong performance across the region (Table 2).

Bagmati province recorded 88.2% total vaccination coverage, while Gandaki reported 75.8%, with Gandaki vaccinating only 100,990 of its 133,254-target population. Both provinces also showed internal inequities with mean coverage of Bagmati 71.4%, Gandaki: 71.8%, lowest district coverage: Bagmati: 45.2%, Gandaki: 45.9%, coverage range (maximum – minimum): Bagmati: 70.4-115.6%, Gandaki: 45.5-91.4%. These disparities highlight that some districts performed far below others, despite reasonable aggregate performance (Table 3).

Koshi Province exhibited the largest range in district-level vaccination coverage, spanning 65.7 percentage points (from approximately 59.0% up to 124.7%), signaling both substantial underperformance and overachievement within the province. Koshi's mean coverage (83.4%) exceeded its median (79.5%), reflecting a positive skew. In contrast, Karnali Province had the smallest coverage range, just 30.9 pts (from roughly 85.3% to 116.2%), and maintained a high mean of 98.6%, suggesting more uniform and consistently strong district-level outcomes. Lumbini and Sudurpaschim provinces had mean coverage around 90-92%, with moderate ranges (48.2% and 36.4%, respectively), suggesting balanced but not exceptional performance.

Proportion of Target Population

Proportion of target population (out of total estimated population) for IPV vaccination campaign varied across Nepal's seven provinces, ranging from 4.7% in Madhesh to 5.7% in Sudurpaschim, against the national average of 5.0% (Table 1). In terms of numbers, Bagmati province had the

Table 1. Province-Wise Target Population and Coverage Achieved in Nepal's IPV Vaccination Campaign

Province	Total Population	Target Population	Proportion of Total Population	Target Achieved	Target Achieved %
Koshi	49,65,744	2,48,093	5.0%	2,38,208	96.0%
Madhesh	62,39,952	2,92,959	4.7%	3,27,070	111.6%
Bagmati	62,62,412	3,03,773	4.9%	2,67,999	88.2%
Gandaki	24,03,527	1,33,254	5.5%	1,00,990	75.8%
Lumbini	51,53,505	2,53,079	4.9%	2,45,451	97.0%
Karnali	17,04,171	86,850	5.1%	87,421	100.7%
Sudurpaschim	26,67,499	1,44,704	5.4%	1,36,220	94.1%
National	2,93,96,810	14,62,712	5.0%	14,03,359	95.9%

Table 2. Province Wise Performance target population and vaccination coverage (Mean, Median and Range)

Province	Target Population (% of total population)					IPV Vaccination Coverage (%)				
	Minimum	Maximum	Range	Mean Target	Median Target	Minimum	Maximum	Range	Mean Coverage	Median Coverage
Koshi	4.6%	6.3%	1.7%	5.5%	5.7%	59.0%	124.7%	65.7%	83.4%	79.5%
Madhesh	4.5%	4.9%	0.4%	4.7%	4.7%	90.6%	124.2%	33.6%	111.8%	116.3%
Bagmati	3.6%	6.8%	3.2%	5.2%	5.3%	45.2%	115.6%	70.4%	79.1%	76.3%
Gandaki	3.8%	6.6%	2.8%	5.6%	5.9%	45.9%	91.4%	45.5%	71.8%	70.7%
Lumbini	4.4%	6.8%	2.4%	5.3%	5.3%	67.4%	115.6%	48.2%	90.7%	91.9%
Karnali	4.4%	5.8%	1.4%	5.1%	4.9%	85.3%	116.2%	30.9%	98.6%	98.3%
Sudurpaschim	5.0%	6.6%	1.6%	5.7%	5.8%	72.6%	109.0%	36.4%	91.7%	92.9%

Table 3. District Wise Targeted Population and Coverage Achieved during IPV Vaccination Campaign in Nepal

Province	District	Total Population	Target Population	Target Population (%)	Target Achieved#	Target Achieved (%)
Koshi	Taplejung	1,12,894	6,711	5.9	6,363	94.8
Koshi	Sankhuwasabha	1,54,208	8,131	5.3	6,971	85.7
Koshi	Solukhumbu	1,02,156	5,242	5.1	4,198	80.1
Koshi	Okhaldhunga	1,33,426	7,931	5.9	4,680	59.0
Koshi	Khotang	1,63,494	9,653	5.9	7,311	75.7
Koshi	Bhojpur	1,48,774	8,520	5.7	6,243	73.3
Koshi	Dhankuta	1,47,374	8,898	6.0	6,085	68.4
Koshi	Terhathum	84,960	5,361	6.3	3,835	71.5
Koshi	Panchthar	1,64,714	10,238	6.2	8,085	79.0
Koshi	Ilam	2,73,779	15,477	5.7	9,563	61.8
Koshi	Jhapa	10,17,386	46,346	4.6	46,884	101.2
Koshi	Morang	11,69,950	53,644	4.6	58,083	108.3
Koshi	Sunsari	9,52,037	43,821	4.6	54,660	124.7
Koshi	Udayapur	3,40,592	18,120	5.3	15,247	84.1
Madhesh	Saptari	7,15,323	34,711	4.9	31,432	90.6
Madhesh	Siraha	7,47,514	35,010	4.7	43,441	124.1
Madhesh	Dhanusa	8,79,495	40,254	4.6	38,312	95.2
Madhesh	Mahottari	7,16,264	34,388	4.8	36,914	107.3
Madhesh	Sarlahi	8,78,191	41,464	4.7	48,252	116.4
Madhesh	Rautahat	8,41,191	37,847	4.5	45,689	120.7
Madhesh	Bara	7,84,804	37,473	4.8	43,534	116.2
Madhesh	Parsa	6,77,170	31,812	4.7	39,496	124.2
Bagmati	Dolakha	1,66,055	9,899	6.0	5,436	54.9
Bagmati	Sindhupalchok	2,50,350	14,974	6.0	10,100	67.5
Bagmati	Rasuwa	45,974	2,245	4.9	1,713	76.3
Bagmati	Dhading	3,15,277	18,263	5.8	12,168	66.6
Bagmati	Nuwakot	2,54,210	14,611	5.7	10,455	71.6
Bagmati	Kathmandu	21,43,289	98,038	4.6	1,00,670	102.7
Bagmati	Bhaktapur	4,72,330	16,769	3.6	19,393	115.6
Bagmati	Lalitpur	5,86,443	25,957	4.4	24,416	94.1
Bagmati	Kavrepalanchok	3,56,350	20,199	5.7	14,520	71.9
Bagmati	Ramechhap	1,60,046	10,932	6.8	4,946	45.2
Bagmati	Sindhuli	2,98,118	15,737	5.3	12,700	80.7
Bagmati	Makwanpur	4,71,153	22,497	4.8	19,323	85.9
Bagmati	Chitawan	7,42,817	33,652	4.5	32,159	95.6

Province	District	Total Population	Target Population	Target Population (%)	Target Achieved#	Target Achieved (%)
Gandaki	Gorkha	2,36,396	13,908	5.9	8,502	61.1
Gandaki	Manang	5,938	270	4.5	124	45.9
Gandaki	Mustang	15,065	576	3.8	520	90.3
Gandaki	Myagdi	1,01,824	5,994	5.9	4,252	70.9
Gandaki	Kaski	6,16,760	28,307	4.6	25,822	91.2
Gandaki	Lamjung	1,47,148	9,182	6.2	5,888	64.1
Gandaki	Tanahu	3,11,291	18,581	6.0	13,146	70.7
Gandaki	Nawalparasi (E)	3,81,615	18,399	4.8	16,818	91.4
Gandaki	Syangja	2,32,215	14,633	6.3	9,336	63.8
Gandaki	Parbat	1,21,676	8,044	6.6	5,426	67.5
Gandaki	Baglung	2,33,599	15,360	6.6	11,156	72.6
Lumbini	Rukum (East)	55,859	2,885	5.2	2,619	90.8
Lumbini	Rolpa	2,31,221	12,522	5.4	11,662	93.1
Lumbini	Pyuthan	2,22,538	13,179	5.9	11,657	88.5
Lumbini	Gulmi	2,28,999	14,744	6.4	10,506	71.3
Lumbini	Arghakhanchi	1,63,552	11,197	6.8	7,544	67.4
Lumbini	Palpa	2,33,471	13,878	5.9	9,736	70.2
Lumbini	Nawalparasi	3,92,521	18,246	4.6	18,947	103.8
Lumbini	Rupandehi	11,60,481	50,604	4.4	58,496	115.6
Lumbini	Kapilbastu	6,99,870	31,467	4.5	33,192	105.5
Lumbini	Dang	6,82,501	32,261	4.7	36,406	112.8
Lumbini	Banke	6,22,345	28,251	4.5	26,874	95.1
Lumbini	Bardiya	4,60,147	23,845	5.2	17,812	74.7
Karnali	Dolpa	43,525	1,980	4.5	1,912	96.6
Karnali	Mugu	65,985	2,926	4.4	2,800	95.7
Karnali	Humla	56,317	2,714	4.8	2,617	96.4
Karnali	Jumla	1,19,130	5,828	4.9	5,704	97.9
Karnali	Kalikot	1,47,289	7,348	5.0	7,398	100.7
Karnali	Dailekh	2,46,254	14,300	5.8	14,139	98.9
Karnali	Jajarkot	1,93,482	9,300	4.8	9,174	98.6
Karnali	Rakum (West)	1,73,020	8,803	5.1	8,774	99.7
Karnali	Salyan	2,34,925	13,586	5.8	11,588	85.3
Karnali	Surkhet	4,24,244	20,065	4.7	23,315	116.2
Sudurpaschim	Bajura	1,36,891	7,433	5.4	8,099	109.0
Sudurpaschim	Bajhang	1,82,203	10,897	6.0	10,855	99.6
Sudurpaschim	Darchula	1,32,105	7,226	5.5	6,020	83.3
Sudurpaschim	Baitadi	2,36,634	13,678	5.8	10,915	79.8
Sudurpaschim	Dadeldhura	1,37,095	7,989	5.8	5,801	72.6
Sudurpaschim	Doti	1,98,586	11,663	5.9	10,831	92.9
Sudurpaschim	Achham	2,17,319	14,403	6.6	13,593	94.4
Sudurpaschim	Kailali	9,09,812	45,155	5.0	46,071	102.0
Sudurpaschim	Kanchanpur	5,16,854	26,260	5.1	24,035	91.5

largest target population at 303,773 children, while Karnali had the smallest at 86,850.

Madhesh had the smallest range (0.4%, from 4.5% to 4.9%), reflecting high uniformity in the proportion of the population targeted across its districts. On the contrary, Bagmati showed the widest range (3.2%, from 3.6% to 6.8%), indicating significant variability in the proportion of the population targeted across its districts. This reflects diverse population densities or strategic priorities (e.g., urban Kathmandu vs. rural areas).

Gandaki and Sudurpaschim provinces had the highest median target proportions (5.9% and 5.8%, respectively), slightly above the national trend, while Madhesh has the lowest (4.7%).

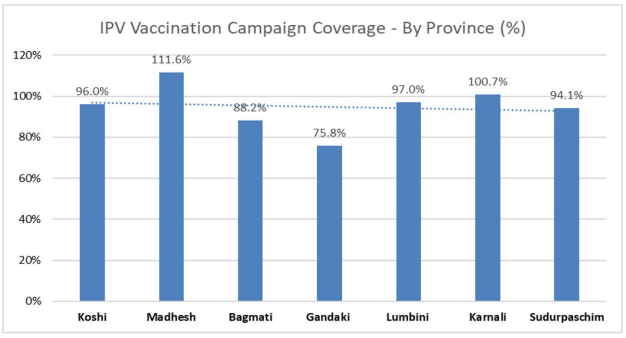

Figure 1. IPV Vaccination Coverage during Campaign – by Province.

Relationship Between Target Proportion and Coverage

No clear correlation exists between the target population proportion and vaccination coverage. For example, provinces with higher mean target proportions, such as Sudurpaschim (5.7%), do not necessarily exhibit higher mean coverage (91.7%), whereas Madhesh, with a lower mean target proportion (4.7%), achieved the highest mean coverage (111.8%). This suggests that the success of vaccination coverage may depend more on implementation efficiency than on the proportion of the population targeted. Disparities in the proportion of the target population across provinces raise concerns about equity. For instance, provinces like Bagmati and Gandaki, where the mean target population exceeds 5% (5.2% and 5.6%, respectively), report low mean coverage (79.1% and 71.8%) and wide ranges (70.4% and 45.5%), in contrast to Madhesh, which targeted less than 5% population (4.7%) yet achieved over 100% coverage (mean 111.8%). These differences may indicate challenges in reaching targeted groups, potentially due to geographic, logistical, or operational barriers.

DISCUSSIONS

Nepal's 2024 IPV vaccination campaign, targeting the 'unvaccinated cohort' of approximately 1.46 million children born between April 2016 and October 2018, with a national coverage rate of 95.9% marks a significant public health achievement. This success reflects the health system's capacity to mobilize resources, coordinate with international partners like WHO and UNICEF, and leverage the strengths of local governments to address a critical immunity gap caused by the global IPV shortage.

In contrast, published literature reveals that many countries introducing IPV vaccination - in their routine immunization have struggled to meet the WHO's recommended 90% coverage threshold. For instance, Sindh Province in Pakistan (82% based on finger-marking during post-campaign coverage assessment), Sokoto state in Nigeria (87%), Bangladesh (65%), and Ethiopia (38%).[6-9]

These variations in vaccination uptake across countries and regions result from a complex interaction of factors, including healthcare infrastructure and access, logistical and supply chain challenges, socioeconomic disparities, cultural beliefs and vaccine hesitancy, government policy and funding, campaign design and delivery strategies, and external disruptions like natural calamities.[10-13] Nepal's achievement, therefore, stands out as a notable example of effective immunization planning and execution amidst such diverse influences.

Disparities in Coverage:

Widespread coverage disparities are evident at every level – provincial, district, and sub-district. Significant provincial disparities in IPV vaccination campaign coverage indicate systemic inequities that threaten the long-term efficacy of Nepal's NIP. Madhesh province excels with high, consistent coverage (mean 111.84%) and minimal variation in target proportion (range 0.4%). Bagmati shows the greatest variability in both target proportion (range 3.2%) and coverage (range 70.4%), with the lowest overall coverage (mean 71.43%). Karnali achieves high coverage (mean 98.6%) with the smallest coverage range (30.9%), indicating equitable and effective implementation.

Bagmati and Gandaki provinces with 88.2% and 75.8% coverages, respectively, fell below the 90% coverage benchmark. Their mean district coverages of 79.1% and 71.8%, respectively, and wide ranges (70.4% and 45.5%), further indicate inconsistent performance across districts. These provinces with lower coverage may have faced operational constraints, such as scattered target population, inadequate staffing, vaccine stockouts, or poor data reporting, which administrative records alone cannot fully uncover.

Low minimum coverage in a district of Bagmati province (45.2%) is particularly concerning, given its inclusion of Kathmandu, Nepal's urban capital in the same province, alongside rural districts like Dolakha, suggest urban-rural divide, combined with logistical bottlenecks, hindering vaccine delivery. Studies have also shown other reasons behind the low IPV vaccine uptake, including a lack of awareness about the vaccine, limited access to health-care facilities, dissatisfaction with vaccination services, and fear of vaccine side effects.[8]

Poor performance of districts in Gandaki province like Manang (45.9%) and Gorkha (61.1%), as well as those in other provinces such as Ramechhap (45.2%), Dolakha (54.9%), points to logistical challenges like difficult terrain, limited health infrastructure and transportation, and sparse population distribution associated with possibly weaker community mobilization in hilly and mountainous regions (Fig. 2).[8] On the contrary, good performance by districts in Karnali province (mean coverage 98.6%, range 30.9%) in the mountainous northwest highlights the potential for success in remote areas when logistical planning and resource allocation are prioritized. Socioeconomic factors, such as poverty and education levels, may also play a role,

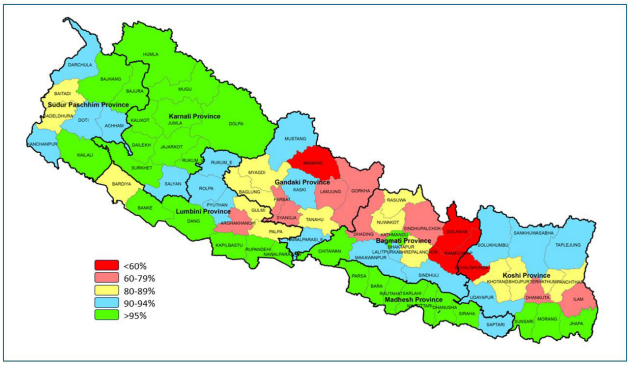

Figure 2. Choropleth map of Nepal showing district level variation in IPV vaccination coverage.

though the lack of demographic data limits deeper equity analysis. Ceccarelli et al. in their study showed that living in a lowland area rather than a mountainous area was found to increase vaccine acceptance for all the vaccinations.[14]

Coverage exceeding 100% in Madhesh and Karnali provinces (111.6% and 100.7%, respectively) as well as in certain districts such as Sunsari (124.7%), Parsa (124.2%), and Surkhet (116.2%) indicates that the campaign reached beyond initial estimates. No published research could be found mentioning more than 100% IPV coverage in other countries which have implemented IPV vaccination campaign.

Overall, the vaccination coverage at district-level ranged from 124.7% (Sunsari in Koshi) and 45.2% (Ramechhap in Bagmati), a difference of 79.5 percentage points. This wide range underscores significant district level variations in campaign implementation. Other studies have described reasons for localized variations in coverage due to difference infrastructure, geography, socioeconomic conditions, cultural attitudes, and operational effectiveness.[15] This needs further study and exploration to gain more insight on this.

Urban districts such as Kathmandu (102.7%), Bhaktapur (115.6%), Rupandehi (115.6%), and Kailali (102.0%) generally outperformed rural districts like Ramechhap (45.2%), Manang (45.9%), and Dadeldhura (72.6%). This suggests that urban areas benefited from better infrastructure, accessibility, and possibly higher awareness. This could also be possibly due to target population underestimation considering the migration of people from rural areas to urban cities in search of better opportunities for education and employment. A systematic review to assess vaccination equity in low- and middle-income countries also showed that vaccine coverage, including full immunisation coverage, was higher in urban areas of Brazil, Cameroon, Ethiopia, India, Madagascar, Malawi, Myanmar, Tanzania, Pakistan, and Vietnam.[16,17]

Implications for Strengthening the NIP

The IPV campaign's data-to-action potential lies in its ability to pinpoint where and why disparities occur, guiding targeted interventions. Madhesh province success in the plains suggests strong community trust and outreach, access to the service while Karnali's success in the mountains highlights effective logistics management in hard-to-reach areas. It is essential to explore this more thoroughly for scaling the best practices such as enhanced training for health workers, real-time supply chain monitoring, and localized awareness campaigns could strengthen immunization coverage in relatively low performing provinces.[18-20]

Addressing geographic barriers requires investment in cold chain infrastructure, particularly in hilly and mountainous districts where coverage lagged compared to those in plain regions. Mobile vaccination units, drone delivery systems, or satellite-guided logistics already piloted in other low-resource settings could mitigate terrain-related challenges.[18,21-23] Additionally, improving data quality is paramount. The reliance on target projections from 2011 census figures and unverified administrative reports risks misestimating target populations, as seen in coverage exceeding 100%. Integrating household survey findings accounting migrant families, or real-time digital tracking into future campaigns could enhance accuracy and equity analysis, especially for marginalized groups.

The campaign's timing, following years of immunity gaps, underscores the urgency of proactive supply chain management. Nepal's vulnerability to global shortages, as experienced in 2016-2018, necessitates regional stockpiling and stronger partnerships with vaccine manufacturers and donors. Embedding IPV catch-up strategies into routine immunization could prevent future 'unvaccinated cohorts,' ensuring sustained protection against Type-2 poliovirus and VDPV risks.

Despite Nepal's official polio-free status since March 2014, the porous border facilitates high daily cross-border movement of migrants, traders, and pilgrims, some from areas with suboptimal immunization coverage in India, posing ongoing importation threats.[25,26] In addition, Nepal's detection of circulating vaccine derived poliovirus type 3 (cVDPV3) in Kathmandu sewage in July 2024 though no paralytic cases were reported provides a crucial early warning signal, underscoring the need for continued environmental surveillance, attention to immunization coverage gaps, and ongoing refinements in vaccination strategy to prevent even rare, high-risk strains like cVDPV3 from establishing local transmission.[27]

Nepal's geographically challenging terrain, coupled with the presence of mobile and hard-to-reach populations, and resource constraints within the health system, significantly increase operational challenges in delivering immunization services.[28] These factors contribute to gaps in immunization coverage, particularly among marginalized groups such as migrants, ethnic minorities, and urban poor.[29] Additionally, public fatigue and a reduced perceived risk of vaccine-preventable diseases following polio certification may further undermine immunization efforts. Addressing these

challenges requires sustained commitment to equitable access, enhanced community engagement, and robust health system strengthening to ensure comprehensive immunization coverage across all populations.[25]

The use of administrative data introduces potential biases, such as overestimation from duplicate reporting or underestimation due to incomplete records, common in remote areas and low-resource settings. The analysis does not account for campaign duration variations which ranged from 10 to 14 days due to logistical scheduling, nor does it consider the impact of concurrent health interventions that may have influenced IPV uptake. Additionally, the dataset lacks demographic details (e.g., age, gender, socioeconomic status), limiting the ability to conduct a detailed equity analysis.

CONCLUSION

Overall, the findings highlight disparities in vaccination campaign performance across Nepal, with implications for resource allocation, equity, and future public health strategies. However, the campaign's outcomes reveal a complex interplay of strengths and challenges, with provincial and district-level disparities underscoring the need for tailored strategies to strengthen Nepal's NIP. The administrative-reported coverage data analyzed in this study provide actionable insights into coverage patterns, operational efficiencies, and systemic inequities, offering a roadmap for enhancing immunization efforts across Nepal's diverse landscape.

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